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EDITORIAL

CIGARETTE TOBACCO

WITHIN the last five years the import of manufactured cigarettes, other than beedies, into Ceylon has fallen off from over half a million pounds weight to less than one-fifth of this quantity. It is not that the public have more generally taken to smoking beedies or Jaffna cheroots but that the ubiquitous cigarette is now being manufactured in Ceylon from imported tobacco leaf. This is shown by the fact that unmanufactured leaf has increased fivefold, to about the former quantity of cigarettes. Progress has therefore been made in the manufacture of cigarettes in the Island and the possibilities of a Ceylon grown leaf for the purpose are considerable. Whilst some measure of success had been achieved in the manufacture from locally grown materials of chewing tobacco, pipe mixtures and a full flavoured cigar, the production of a leaf suitable for cigarettes had not been developed.

A thin leaf comparatively free from the blemishes caused by disease is not altogether easy of production on account of the great humidity of our atmosphere. Nevertheless, promising

types of leaf are now under experiment and the necessary preliminary work on the management of seed beds, spacing, rotation, manuring and the problems of insect and fungus pests has now been done. The methods of curing the leaf as at present practised range from burying it *en masse* in the soil to carefully picking the leaves as they ripen and drying them in the air.

None of these methods will do for the leaf of the connoisseur's cigarette. For this controlled curing artificial heat is necessary. A flue-curing house has been designed and experimented with and a measure of success which may be called a distinct advance has been made. It is believed that the production of a light leaf that will be acceptable at least as a blend in Ceylon manufactured cigarettes will shortly be realised.

THE CHANGE IN COMPOSITION AND DECOMPOSABILITY OF TYPICAL CEYLON GREEN MANURES WITH AGE

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INTRODUCTION

THE investigations with which this paper deals were completed some time ago, but for various reasons their publication had to be deferred. In view of the interest taken by agriculturists in this subject and the likelihood of the initiation of work of a similar nature by the Research Institutes, it is desirable that the data obtained in this laboratory be made available. Two series of experiments were carried out, the first having been completed in May, 1930 and the second in February, 1932. The investigations were confined to typical Ceylon bush and tree green manure crops only, as the relative information in regard to cover crops was already available, and as the problem of lignification or development of woody tissue does not arise with the latter types of green manure plants.

OBJECTS

The objects of the investigations were to determine: (1) the change in chemical composition of typical tree and bush green manure loppings with age, (2) the relative amounts of green manure material obtainable at different periods of growth, (3) the decomposability of the materials so obtained by chemical methods, and (4) the optimum time for cutting such green manure crops in order to secure the maximum amounts of easily decomposable plant material.

EXPERIMENTAL

For each type of green manure, two representative and commonly grown varieties were selected for experiment. *Crotalaria anagyroides* and *Tephrosia candida* (boga medeloa) were

the bush types and *Erythrina lithosperma* (dadap) and *Gliricidia maculata* the tree types. In the first series of trials both types were included, while in the second only the tree crops were studied.

SERIES I

The bush green manures were grown in two adjoining plots in one area and the trees in another area. The latter had been established for three or four years when the experiment started, but in accordance with Ceylon estate practice, had had their branches periodically lopped. They were all lopped at the start of the experiment and the shoots labelled as they appeared on each tree. The ages of the branches were thus recorded. Branches of different ages were cut from time to time in duplicate for analyses. The bush plants were grown from seed. Two samples of two plants each were cut to ground level, at different stages of growth of the plants. Records were kept of weights of leaf and stem respectively, and separate analyses made of the latter.

In addition to the ordinary analytical determinations, estimations were made of the pentosan and lignin contents of the stems and of a representative sample of the leaves. Lignin was determined by Schwalbe's method as described by Waksman [1] and pentosan by the ordinary phloroglucide method. The results are detailed in Tables I to V. Tables I, II and V show the analytical composition of leaf, stem and plant or branch, and Tables III and IV the amounts of dry matter and the total nitrogen and ash contents in the plant materials at different ages. In the tables the letter *L* signifies leaf, *S* stem, *P* whole plant, branch or loppings as the case may be. The percentage constituents are calculated on dry matter at 100°C, but the moisture on green material is also shown. The data shown are the means of duplicates. The total constituents are expressed in grams.

RESULTS AND DISCUSSION

An examination of Tables I and II would indicate that (1) the nitrogen, ash, lime, potash and phosphoric acid contents of the leaf, stem and whole plant or branch decrease steadily while the dry matter contents increase, as the crops advance in age. The diagram illustrates this in part, in the case of *Crotalaria* and *Gliricidia*. The greatest falls occur with nitrogen in the whole plant or branch and the least with potash. Thus the nitrogen in *Crotalaria* diminishes from 3·52 to 0·96 per cent., while the potash in the same crop correspondingly falls from 3·11 to 1·98

TABLE I

PERCENTAGE CONSTITUENTS OF LEAF, STEM AND PLANT

Bush Green Manures

Plant	Age in months	On green material									On dry material at 100°C											
		Moisture			Organic matter			Ash			Nitrogen			Potash			Lime		Phos. Acid		
		L	S	P	L	S	P	L	S	P	L	S	P	L	S	P	L	S	P	L	S	P
	4	82·8	84·2	83·4	87·8	92·4	89·7	12·2	7·6	10·3	4·73	1·70	3·52	3·68	—	—	1·76	—	—	0·78	—	—
	4	81·4	77·0	79·4	88·9	93·0	90·9	11·1	7·0	9·1	4·45	1·28	2·88	3·40	2·83	3·11	1·69	1·23	1·46	0·77	0·52	0·64
Crotalaria	5	81·6	73·8	78·0	89·5	93·7	92·1	10·5	6·3	7·9	4·06	0·95	2·12	3·31	2·31	2·67	1·43	0·91	1·11	0·72	0·48	0·57
anagyroides	6*	79·2	72·4	75·5	90·5	94·6	93·0	9·5	5·4	7·0	4·11	0·66	2·01	3·18	2·04	2·48	1·39	0·77	1·01	0·69	0·40	0·51
	7½	78·2	67·6	71·1	91·6	95·0	94·2	8·4	5·0	5·8	3·78	0·57	1·37	2·86	1·87	2·12	1·20	0·52	0·69	0·67	0·28	0·38
	8½	77·5	60·1	68·7	92·0	95·7	95·1	8·0	4·3	4·9	3·35	0·47	0·96	2·28	1·93	1·98	1·12	0·51	0·61	0·51	0·20	0·27
	4	74·9	74·4	74·6	90·8	92·7	91·5	9·2	7·3	8·5	4·07	1·53	3·23	1·81	—	—	1·90	—	—	0·78	—	—
	5	71·9	71·9	71·9	91·2	94·6	92·3	8·8	5·4	7·7	4·06	1·17	3·15	1·61	1·45	1·55	1·86	0·74	1·50	0·76	0·29	0·51
Tephrosia	6	72·0	68·1	70·2	92·4	95·8	94·0	7·6	4·2	6·0	3·76	0·99	2·45	1·53	1·28	1·41	1·62	0·55	1·11	0·71	0·29	0·51
candida	7	72·4	64·6	68·5	92·8	96·2	94·6	7·2	3·8	5·4	·61	0·83	2·03	1·37	1·12	1·22	1·54	0·39	1·26	0·66	0·23	0·42
	8*	71·9	63·2	67·4	93·0	96·5	95·0	7·0	3·5	5·0	3·59	0·71	1·88	1·44	1·06	1·21	1·48	0·37	0·82	0·60	0·22	0·37
	9	69·2	61·8	64·9	93·2	96·8	95·5	6·8	3·3	4·5	3·03	0·63	1·51	1·28	0·89	1·03	1·37	0·35	0·72	0·42	0·18	0·27
	10	67·8	59·4	61·7	94·2	97·0	96·3	5·8	3·0	3·7	·99	0·46	1·06	1·22	0·90	0·98	1·28	0·33	0·55	0·31	0·17	0·21

* Flowering Stage.

TABLE II

PERCENTAGE CONSTITUENTS OF LEAF, STEM AND BRANCH

Tree Green Manures

Plant	Age in months	Thickness of stem cms.	On green material						On dry material at 100°C														
			Moisture			Organic matter			Ash			Nitrogen			Potash			Lime			Phos. Acid		
			L	S	P	L	S	P	L	S	P	L	S	P	L	S	P	L	S	P	L	S	P
	3½	2·2	77·7	79·0	78·4	91·1	95·5	93·3	8·9	4·3	6·7	3·69	1·08	2·45	1·98	1·29	1·66	2·04	0·61	1·35	0·78	0·31	0·55
Erythrina	4½	2·4	77·3	78·4	77·8	91·9	95·8	93·6	8·1	4·2	6·4	3·93	1·03	2·64	1·81	1·21	1·60	1·86	0·56	1·27	0·68	0·32	0·52
lithosperma	5½	2·7	77·2	77·6	77·5	92·7	96·9	95·2	7·3	3·1	4·8	3·72	·86	2·01	1·68	1·12	1·34	1·65	0·54	0·99	0·61	0·28	0·41
(Dadap)	6½	3·0	77·1	76·2	76·5	93·1	97·1	95·7	6·9	2·9	4·3	3·14	·81	1·66	1·42	0·96	1·13	1·43	0·54	0·81	0·50	0·26	0·35
	8	3·9	73·9	68·8	70·2	93·8	97·2	96·4	6·2	2·8	3·6	2·87	·69	1·20	1·56	0·85	1·01	1·35	0·52	0·72	0·54	0·27	0·33
	3	1·9	74·8	73·1	73·8	89·5	96·0	93·1	10·5	4·0	6·9	3·28	1·14	2·13	2·55	0·94	1·69	2·46	0·49	1·38	0·65	0·23	0·42
Gliricidia	4	2·4	74·2	72·2	73·0	90·0	96·2	93·6	10·0	3·8	6·4	3·38	·90	1·93	1·83	0·93	1·32	1·85	0·44	1·02	0·62	0·22	0·38
maculata	5	2·6	73·6	70·9	71·5	90·2	96·2	93·8	9·9	3·8	6·2	3·31	·79	1·80	1·52	0·92	1·16	1·78	0·40	0·95	0·56	0·20	0·35
	6	3·7	73·3	69·8	70·7	90·8	96·6	95·1	9·2	3·4	4·9	3·16	·78	1·38	1·37	0·90	1·02	1·68	0·33	0·68	0·48	0·19	0·27

per cent.; (2) as has been found in previous analyses of local green manure plants [2, 3, 4], of the fertilising constituents nitrogen is highest and phosphoric acid lowest in both leaf and stem. Potash and lime are intermediate, the former being higher in all cases. The percentages of these constituents will, however, vary with soil, climatic and crop conditions; (3) the percentages of nitrogen and ash constituents are much higher in the leaf than in the stem, those in the whole plant or branch being intermediate between the two. The percentage nitrogen contents of the stem are from about one-third to one-sixth and the ash contents from about one-half to one-third that of the leaf; (4) the mean thickness of the dadap and *Gliricidia* branches increases fairly rapidly with age i.e. from 2·2 cm. at three and a half months to 3·9 cm. at eight months in the case of the former, and from 1·9 cm. to 3·7 cm. at three and six months, respectively in the case of the latter.

From Tables III and IV it will be observed that (1) that the ratios of leaf to stem fall rapidly as the crops advance in age, this being particularly so in the case of the bush types. The ratios fall from about 2 to ·3 in the latter and from about 1 to ·3 in the tree types; (2) the total amounts of nitrogen increase as the crops advance in age except in the case of *Tephrosia* which shed its leaves a little time after flowering. The increase is most marked just about the time of flowering in *Crotalaria* and *Tephrosia*. With the tree types the increase is more gradual. In every instance the leaves contain the largest amounts of nitrogen. The amounts of ash too increase with age with the exception of *Tephrosia* where again there is a slight decrease a short time after flowering. The total dry matter increases with age in all cases.

A glance at Table V will show that the pentosan contents and pentosan/lignin ratios of the stems decrease and the lignin contents increase as the crops advance in age.

The above results bear out, in general, the work of Leukel, Barnette and Hestor [5], Koch [6] and Brown & Stallings [7] in regard to the analytical composition of bush green manure plants. No previous work on these lines had been carried out with tree green manure crops.

In regard to the cutting of these green manure plants, it will be agreed that the object aimed at should be the securing of the largest possible amounts of easily-decomposable green

TABLE III

TOTAL CONSTITUENTS IN DRY MATTER IN GRAMS

Bush Green Manures

Plant	Age in months	Leaf Dry matter	Leaf Ash	Leaf Nitrogen	Stem Dry matter	Stem Ash	Stem Nitrogen	Plant Dry matter	Plant Ash	Plant Nitrogen	Dry matter Ratio L/S
	4	6·5	·8	·3	4·3	·3	·1	10·8	1·1	·4	1·5
	4	31·6	3·5	1·4	30·6	2·1	·4	62·2	5·6	1·8	1·0
	5	177	18·5	7·2	293	18·4	2·8	470	36·9	10·0	0·6
Crotalaria anagyroides	6*	228	21·7	9·4	356	19·2	2·3	584	40·9	11·7	0·6
	7½	272	22·8	10·3	815	40·7	4·6	1088	63·5	14·9	0·3
	8½	313	25·1	10·5	1540	65·8	7·2	1853	90·9	17·7	0·2
	4	7·0	·6	·3	2·9	·2	·04	9·9	·8	·34	2·4
	5	37·1	3·2	1·5	16·9	·9	·2	54·0	4·1	1·7	2·2
	6	68	5·2	2·6	61	2·6	·6	129	7·8	3·2	1·1
Tephrosia candida	7	115	8·3	4·1	152	6·0	1·3	267	14·3	5·4	0·8
	8*	288	10·3	10·3	419	14·8	3·0	7·07	35·1	13·3	0·7
	9	385	26·3	11·7	660	21·7	4·2	1051	48·0	15·9	0·6
	10	287	16·6	8·6	930	28·3	4·3	1217	44·9	12·9	0·3

* Flowering Stage

TABLE IV

TOTAL CONSTITUENTS IN DRY MATTER IN GRAMS

Tree Green Manures

Plant	Age in months	Leaf Dry matter	Leaf Ash	Leaf Nitrogen	Stem Dry matter	Stem Ash	Stem Nitrogen	Branch Dry matter	Branch Ash	Branch Nitrogen	Dry matter Ratio L/S
Erythrina lithosperma (Dadap)	3½	48·1	4·3	1·8	43·7	1·8	·5	91·8	6·1	2·3	1·1
	4½	81·9	6·6	3·2	64·4	2·7	·7	146	9·3	3·9	1·2
	5½	102	7·4	3·8	151	4·7	1·3	253	12·1	5·1	0·7
	6½	123	8·5	3·9	212	6·0	1·7	335	14·5	5·6	0·5
	8	232	14·5	6·7	766	21·3	5·3	998	35·8	12·0	0·3
Gliricidia maculata	3	106	10·8	3·5	145	5·7	1·6	251	16·5	5·1	0·7
	4	124	12·5	4·2	176	6·6	1·6	300	19·1	5·8	0·7
	5	132	13·1	4·4	200	7·6	1·6	332	20·7	6·0	0·6
	6	181	16·6	5·7	527	18·1	4·1	708	34·7	9·8	0·3

TABLE V

THE PENTOSAN, LIGNIN AND CARBON CONTENTS OF THE GREEN MANURES

Plant	Age in months	Lignin	Pentosan	Pentosan/Lignin Ratio		Carbon (Calc.)		Carbon/Nitrogen Ratio	
		S	S	S	P (Calc.)	S	P	S	P
Crotalaria anagyroides	4	—	—	—	—	46·2	40·3	27·2	11·4
	4	19·6	19·0	·97	1·81	46·5	40·9	36·3	14·2
	5	23·4	16·3	·70	1·41	46·8	41·4	49·9	19·5
	6*	24·8	13·5	·54	1·1	47·3	41·9	70·9	21·8
	7½	26·4	13·5	·51	·81	47·5	42·4	89·8	31·0
	8½	26·6	11·4	·43	·64	47·8	42·8	100·0	44·5
Tephrosia candida	4	—	—	—	—	46·3	41·1	30·0	12·7
	5	16·2	22·8	1·4	2·7	47·3	41·5	40·0	13·1
	6	21·1	18·3	·87	1·8	47·9	42·3	48·1	17·3
	7	21·8	15·9	·73	1·5	48·1	42·6	58·0	21·1
	8*	25·8	13·8	·58	1·2	48·2	42·7	68·8	22·7
	9	25·1	12·7	·50	1·0	48·4	43·0	72·3	28·4
	10	—	—	—	—	48·5	43·3	105·4	40·9
Erythrina lithosperma (Dadap)	3½	18·6	14·3	·77	1·8	47·8	41·9	43·5	17·1
	4½	19·4	14·7	·75	1·6	47·9	42·1	47·1	15·9
	5½	20·8	13·11	·63	1·4	48·4	42·8	56·4	21·6
	6½	22·8	11·7	·50	1·1	48·5	43·0	60·0	28·7
	8	24·6	10·5	·43	·76	48·6	43·8	69·5	36·5
Gliricidia maculata	3	19·5	15·8	·81	1·5	48·0	41·9	42·1	19·2
	4	24·7	13·1	·53	1·4	48·1	42·1	53·5	21·8
	5	29·6	11·7	·40	·94	48·1	42·2	60·0	23·4
	6	34·8	11·0	·31	·58	48·3	42·8	60·3	30·8

* Flowering Stage

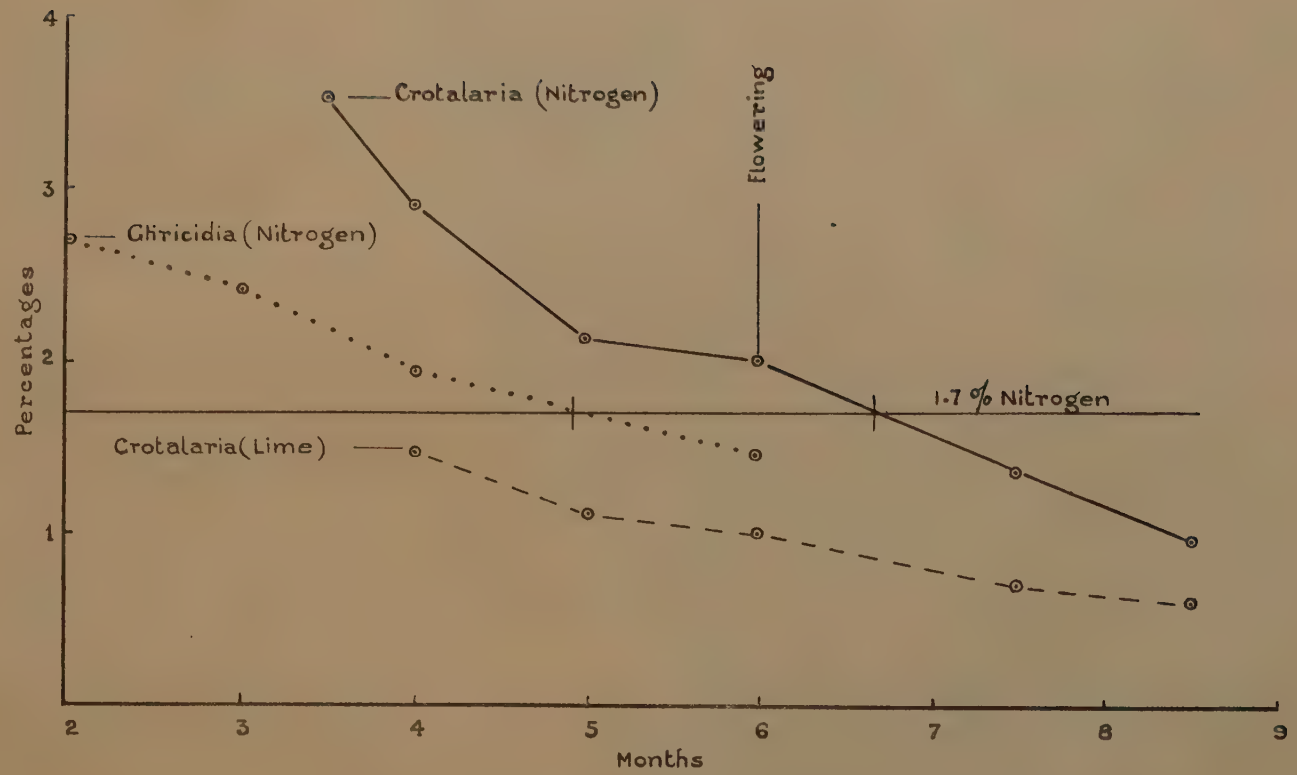

Diagram showing change in composition of green manures with age

material, containing the highest possible proportions of fertilising constituents. Two conditions must be satisfied: the material must be easily decomposable and the amounts of fertilising constituents supplied should be the maximum possible consistent with decomposability. As is well known, the rate and extent of the decomposition of plant materials in the soil will depend on their chemical composition, the presence of the necessary micro-organisms, and the soil temperature and moisture conditions. In regard to the analytical composition of the plant material itself, previous investigators have shown that an adequate quantity of nitrogen to supply the need of the micro-organisms for building up their bodies, and of available carbonaceous material both to meet their energy requirements and to build up their protoplasm, are essential for its decomposition.

Chemical tests for the 'decomposability' of organic materials have been worked out on different lines by Waksman [8], Rege [9] and Jensen [10]. Waksman showed that when the nitrogen content of a material is 1·7 per cent., it is just sufficient to cover the requirements of the micro-organisms active in the decomposition of the plants within a period of four weeks. If the plant material contains more than 1·7 per cent. nitrogen, the excess is rapidly liberated in an available form; if less an additional source of nitrogen will be required before it can be completely decomposed. On this basis, a glance at Tables I and II and the diagram will show that the latest periods after which the loppings of *Crotalaria* and *Tephrosia* will decompose in the soil either very slowly or incompletely, are the sixth and eighth months respectively. These, it will be observed, coincide with the times of flowering of these plants. In the case of dadap and *Gliricidia*, the periods of the minimum nitrogen limit are the sixth and the fifth months respectively for the entire branches. If the stems alone are considered it will be seen that even at the early age of four months they will not readily decompose in the soil. The leaves, on the other hand, are easily decomposable at all ages.

Rege demonstrated that the decomposability of a material can be predicted from a knowledge of the pentosan/lignin ratio of a material. If this was greater than 1 the material would decompose rapidly, if between ·5 and 1 slowly and if below ·5 very slowly. The pentosan he called the 'energy factor' and the lignin the 'inhibitory factor'. Norman [11] showed subsequently, that the cellulose content of plant tissues should be taken into

consideration when any ratio for predicting their decomposabilities was being worked out, as cellulose forms the chief source of carbonaceous material for the organisms decomposing the tissue. As Norman's work had not been published when this investigation was started, the cellulose contents were not taken into consideration. In Table V are shown the pentosan/lignin ratios of the stems, and the calculated pentosan/lignin ratios for the whole plant. This is based on an average pentosan and easily decomposable carbohydrate content of 35 per cent. and a lignin content of 10 per cent. in the leaves. An examination of the table will indicate that on the basis of Rege's test too, the bush plants should not be left uncut after the flowering period, and the tree plants after the fifth or sixth month.

Jensen's method of predicting the decomposability of organic materials is based on the carbon/nitrogen ratios of organic materials. He found that the maximum carbon/nitrogen ratio for the decomposition of these materials in alkaline and neutral soils was 26:1 and 13:1 in acid soils. The soils in this experiment being nearly neutral, 26:1 may be considered the limiting ratio for decomposition. Carbon was calculated on the basis that the organic matter of green manure materials contains about 45 per cent. of this element. This factor was arrived at from the figures of Jensen and Brown and Allison [12], and was confirmed by subsequent analysis in this laboratory. The carbon/nitrogen ratios shown in Table V are therefore only approximate. They are near enough, however, for the purposes of this test. An examination of the data will indicate that they confirm what has been found by the two previous decomposability tests.

It has therefore been established that, from the standpoint of decomposability, the time for cutting bush green manures should not be later than the time of flowering and for lopping the branches of tree green manures not later than the fifth or sixth month. If the stems only are considered, the time of cutting should be much earlier.

The question of determining the period at which the green manure crops should be cut to secure the maximum quantity of easily-decomposable material will next be discussed. The data of Tables I and III show that the loppings of the bush crops as a whole are fairly easily decomposable up to the time of flowering. At this stage the total nitrogen contents of the loppings are 11·7 and 13·3 gm in *Crotalaria* and *Tephrosia* as compared with 17·7 and 12·9 gm respectively at the final sampling. The

increase in total nitrogen subsequent to flowering is mainly brought about by a rapid increase of the low nitrogen-containing and slowly-decomposable stem material. It is obvious therefore that there is no advantage in allowing the plants to pass this stage of growth. Cutting at a much earlier date than flowering would also be disadvantageous as the amounts of decomposable organic matter and nitrogen thus obtained would be much lower than those at the period recommended. Further, if these plants are lopped too young they will not produce a second crop of green material which would be obtained with most bush green manures if lopped when fully grown.

The tree crops too show a sudden rise of dry matter in whole branch after the minimum nitrogen limit is reached. The increases both of dry matter and nitrogen are again largely due to the low nitrogen-containing stem material. From the data in Table IV it would appear that under the conditions of the experiment the most suitable period to lop *Gliricidia* branches would be at six months and dadap branches at eight months, as the nitrogen contents of the leaves alone at these periods are as high, if not higher, than those contained in the entire branches at any previous period. As however in actual practice individual branches are not lopped and there is a fairly great variation in their sizes and leaf contents and as it would not be practicable in all cases to separate leaf material from the branches for turning into the soil, it would be unwise to conclude that the periods stated are those to be recommended for adoption. It was mainly to obtain more conclusive results that the second series of investigations with tree crops, designed to be in accord with agricultural practice, was begun. In considering the data of these trials, the question of the total return of decomposable material during a period of six months or a year will not be overlooked.

SERIES II

This series of experiments was started in May, 1931 in two areas different from the previous ones. As already stated, in this instance only trials with the two varieties of tree green manures viz. *Erythrina* (dadap) and *Gliricidia* were carried out. Eight trees of each variety were lopped on the same day and marked out. Two trees were entirely lopped at the end of each period of two, three, four and six months respectively and the leaf and stem material from each tree separately weighed. Representative samples of these were then taken for analysis. At the

fourth and sixth monthly samplings, the two-monthly and three-monthly lopped trees were re-lopped and the loppings dealt with as previously. An estimate of the amounts of green material from trees lopped at different intervals during a period of six months was thus obtained. The analytical determinations were confined to moisture, ash and nitrogen, the previous investigations having demonstrated that a reliable index of decomposability was obtained from the nitrogen data. The tables show the means of duplicate results.

RESULTS AND DISCUSSION

In Table VI are detailed the analytical composition of leaf and stem material and of the loppings at different times of sampling.

The data in the above table confirm what was found in the previous series that with advancing age the nitrogen and ash contents and leaf to stem ratios fall while the organic matter contents rise. Thus the nitrogen in *Gliricidia* loppings diminishes from 2·69 per cent. at two months to 1·46 per cent. at six months, while that of dadap correspondingly falls from 3·26 to 1·84 per cent. The percentages of nitrogen in this series are however appreciably higher in the case of both *Gliricidia* and dadap than in the previous investigations. The leaves again have a much higher nitrogen content than the stem material, which latter even at the early age of two months has a nitrogen content insufficient for complete decomposition without additional nitrogen. The periods at which the maximum nitrogen content consonant with decomposability is reached are about the fifth month with *Gliricidia* and the sixth month with dadap. This agrees with previous findings.

The table however shows that the secondary loppings from trees lopped more than once have invariably higher nitrogen and generally higher ash contents than the primary loppings. Thus in the case of *Gliricidia* the second and third loppings contain 3·00 and 2·98 per cent. of nitrogen respectively against 2·69 per cent. in the first lopping, while the corresponding figures for dadap are 3·38 and 3·81 per cent. against 3·26 per cent. On the other hand the total amounts of loppings fall considerably with each subsequent lopping. This is clearly seen from Table VII which shows the total amounts of constituents in the dry material.

TABLE VI

PERCENTAGE CONSTITUENTS OF LEAF, STEM AND LOPPINGS

Tree Green Manures

Plant	Sampling	Age in months	On green material Moisture			On dry material at 100°C Organic matter			Ash			Nitrogen		
			L	S	P	L	S	P	L	S	P	L	S	P
Gliricidia maculata	1st	2	80·8	82·3	81·4	89·9	91·5	90·3	10·1	8·5	9·5	3·46	1·47	2·69
	2nd	2	82·1	84·0	82·8	89·3	91·3	90·2	10·7	8·7	10·1	3·68	1·29	3·00
	3rd	2	80·2	82·5	81·4	90·1	91·8	92·2	10·0	8·2	9·5	3·67	1·21	2·98
	2nd after 4 mths.	2	80·1	83·6	81·5	89·6	91·8	90·7	10·4	8·2	9·7	3·71	1·25	2·89
	1st	3	78·8	77·5	78·3	90·6	93·3	91·7	9·4	6·7	8·2	3·36	1·36	2·51
	2nd	3	77·0	73·9	75·9	90·6	93·9	91·9	9·4	6·1	8·2	3·38	1·11	2·52
	1st	4	77·6	73·5	75·6	91·0	94·9	93·1	9·0	5·2	6·9	3·30	0·78	1·96
	1st	6	69·7	65·2	67·0	92·4	96·2	94·7	7·6	3·9	5·2	3·09	0·56	1·46
Erythrina lithos-perma (Dadap)	1st	2	80·2	79·8	80·6	91·5	95·4	92·6	8·5	4·6	7·3	3·95	1·35	3·26
	2nd	2	81·7	78·5	82·3	91·3	94·9	92·2	8·7	5·0	7·2	4·29	1·56	3·38
	3rd	2	81·7	84·5	82·2	91·4	94·8	92·1	8·6	5·2	7·8	4·29	1·89	3·81
	2nd after 4 mths.	2	84·2	86·9	85·1	91·4	94·6	92·2	8·6	5·3	7·8	4·30	1·84	3·54
	1st	3	79·6	77·1	78·6	91·7	96·3	93·7	8·3	3·7	6·4	3·78	1·17	2·69
	2nd	3	79·4	81·1	79·9	91·7	96·0	92·9	8·3	4·0	6·9	3·85	1·32	3·13
	1st	4	78·5	75·1	76·9	92·8	96·5	94·7	7·2	3·5	5·3	3·72	0·98	2·30
	1st	6	74·8	70·5	72·2	92·9	96·7	95·4	7·1	3·2	4·6	3·43	0·95	1·84

TABLE VII

TOTAL CONSTITUENTS IN DRY MATTER IN GRAMS

Tree Green Manures

Plant	Sampling	Age in months	Leaf			Stem			Loppings			Dry matter Ratio L/S
			Organic matter	Ash	Nitrogen	Organic matter	Ash	Nitrogen	Organic matter	Ash	Nitrogen	
Gliricidia maculata	1st	2	467	52·6	18·2	295	27·2	4·5	762	79·8	22·7	1·6
	2nd	2	239	28·5	9·9	113	10·9	1·8	352	39·4	11·7	2·2
	3rd	2	153	16·8	6·4	73·0	6·4	0·9	226·0	23·2	7·3	2·3
	2nd after 4 months	2	388	44·9	15·9	183·8	16·3	2·3	572	61·2	18·2	2·2
	1st	3	1220	126·6	45·4	953·0	69·0	14·1	2173	195·6	59·5	1·3
	2nd	3	1039	108·0	39·0	667	43·5	7·7	1706	151·5	46·7	1·6
	1st	4	1896	187·3	69·0	222·3	120·7	18·1	4119	308·0	87·1	·89
	1st	6	3488	286·3	116·6	6443	258·1	37·2	9931	544·4	153·8	·56
Erythrina lithosperma (Dadap)	1st	2	1043	95·3	44·9	386	18·1	5·4	1429	113·4	50·3	2·8
	2nd	2	606	49·9	25·4	209	13·6	4·5	815	63·5	29·9	2·9
	3rd	2	304	27·2	14·0	68	4·5	1·4	372	31·7	15.4	4·5
	2nd after 4 months	2	522	49·9	24·5	222	13·7	4·1	744	63·6	28·6	2·4
	1st	3	1869	167·8	76·6	1402	54·4	17·2	3271	222·2	93·8	1·4
	2nd	3	1370	122·6	57·6	576	22·7	7·7	1946	145·3	65·3	2·5
	1st	4	2355	181·4	94·4	2613	95·3	26·3	4968	276·7	120·7	·94
	1st	6	1547	118·0	57·2	2844	95·3	27·7	4391	213·3	84·9	·57

It will be observed that the total amounts of organic matter and nitrogen in the first two-monthly *Gliricidia* lopping were 762 and 22·7 gm respectively while the corresponding second and third loppings gave only 352 and 226 gm of organic matter and 11·7 and 7·3 gm of nitrogen—in each case less than half that of the first lopping. The same observations hold good with dadap and with loppings made at other periods of growth. Thus in the case of dadap, the first three-monthly lopping gave 3,271 gm of organic matter and 93·8 gm of nitrogen while the second gave only about half these quantities viz. 1,946 gm of organic matter and 65·3 gm of nitrogen. These figures clearly demonstrate the disadvantage of too frequent lopping of tree green manures. On the whole smaller quantities of organic mater, nitrogen and even of ash will be secured thereby.

In Table VIII are set out the total amounts of fertilising constituents that were obtained by lopping the green manure trees at different times during a period of six months. If the data for *Gliricidia* are considered first, it will be noted that the six month old loppings contain 153·8 gm of nitrogen of which the easily decomposable leaf material contains no less than 116·6 gm, an amount higher than that found in the entire loppings of the two three-monthly lopped or the four and two-monthly lopped samples together. As entire loppings are less easily decomposed than leaf material alone since they contain a proportion of decomposing-resistant stem material, it is obvious that, under the conditions of this experiment, the best time to lop the *Gliricidia* to get the maximum benefit would be at six months after growth. As however a large amount of woody material would be obtained at the same time as the leaf material it would be necessary to cut off the latter from the main branches before it could be forked into the soil. If this cannot be done owing to cost, the trees would have to be lopped at an earlier age, say at four or five months. Early cutting may also be necessary with certain plantation crops where the heavy shade of the green manure trees may be harmful to the former. A further disadvantage of allowing tree crops to become too woody before lopping is that it entails the loss of the mineral fertilising constituents contained in the branches, when the latter are not returned to the soil.

Where there is a likelihood of the shedding of leaves after a certain stage of growth, generally after the nitrogen limit of 1·7 per cent. has been reached, the tree should be lopped earlier

TABLE VIII

TOTAL CONSTITUENTS FOR PERIODS OF SIX MONTHS IN GRAMS

Plant	Lopping intervals in months	Leaf			Stem			Loppings		
		Organic matter	Ash	Nitrogen	Organic matter	Ash	Nitrogen	Organic matter	Ash	Nitrogen
Gliricidia maculata	2	859	97·9	34·5	480	44·5	7·2	1339	142·4	41·7
	3	2259	234·6	84·0	1620	112·5	21·8	3879	369·2	106·2
	4 / 2	2283	232·2	84·9	2406	137·0	20·4	4690	347·1	105·3
	6	3488	286·3	116·6	6443	258·1	37·2	9931	544·4	153·8
Erythrina lithosperma (Dadap)	2	1953	172·4	84·3	735	36·2	11·3	2688	208·6	95·7
	3	3239	290·4	134·2	1978	77·1	24·9	5217	367·5	159·2
	4 / 2	2876	231·3	118·9	2835	109·0	30·4	5711	340·2	149·2
	6	1547	118·0	57·2	2844	95·3	27·7	4391	213·3	84·9

than usual. In these trials the difficulty of leaf shedding was experienced with dadap after the fifth month. The data of Table VIII point to the value of four or even three-monthly loppings under the circumstances. But as too frequent lopping is disadvantageous, it may in general be concluded that an average lopping interval of four to five months would perhaps be best for most soil and climatic conditions.

SUMMARY AND CONCLUSIONS

Two series of investigations designed to study the changes in composition of typical bush and tree green manure crops with age and the optimum periods for cutting them indicate that:

(1) The percentages of nitrogen, ash constituents and pentosan decrease while those of dry matter and lignin increase with advancing age. The leaf material invariably contains higher percentages of the former constituents than the stem material. The absolute percentage constituents vary with different crop, soil and climatic conditions. The leaf to stem ratios of the crops also decrease with age.

(2) In the case of the tree types, where loppings are made every two or three months, the yields of dry matter and fertilising constituents decrease with each successive lopping, though the percentages of nitrogen and ash in them increase. Too frequent lopping of these trees is therefore disadvantageous.

(3) The minimum nitrogen limit for decomposability of lopped material—1·73 per cent. as found by Waksman—is reached just about the time of flowering with bush crops and about the fifth or sixth month from lopping with tree crops. The stem material of even three month old loppings is not readily decomposable. Rege's pentosan/lignin and Jensen's carbon/nitrogen ratio tests for decomposability confirm these conclusions. Subsequent to the periods stated there is a marked increase of the low nitrogen-containing woody material in both types of plants.

(4) From the practical point of view the maximum benefit will be derived by cutting bush green manures at, or just prior to, flowering. With tree crops, the practice will depend on other factors like, *e.g.* subsequent treatment of loppings, amount of shade required by the major crop, period of leaf shedding, etc. These investigations point to the advantage of lopping at about the fifth or sixth month, but in general, a lopping interval of four to five months would be found best for most soil and climatic conditions.

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Cymbidium ensifolium var. *haematodes* Trim.

CYMBIDIUM ENSIFOLIUM VAR. HAEMATODES TRIM.

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CYMBIDIUM is the name given by Swartz to a fairly large group of tropical orchids of the Vanda tribe consisting of both epiphytes and terrestrials. There are about fifty species of the genus, the majority of which are to be found growing in the warm parts of China, Japan, Australia and the Indo-Malayan regions.

Cymbidium ensifolium var. *haematodes* Trim. is a terrestrial, unlike its local relative, *Cymbidium bicolor* which is the commonest epiphyte on the wayside trees at mid and low elevations. It is confined to certain humid zones like Hantane, Galaha, Bogawantalawa and certain parts of Hewagam Korale. Even in these places the plant often escapes notice owing to its long, narrow grass-like leaves, of which it has a tuft which may reach three feet in length, each being half to three quarters of an inch in breadth and borne on a short stem.

The long, worm-like roots are of a creamy white colour. The dull citron-yellow flowers, with pink-veined sepals and petals and a lip beautifully mottled with a darker shade of the same colour, are about two to two and a half inches across and are borne on an erect stalk one and a half to two feet in height.

The plant is worthy of inclusion in any collection of orchids as it flowers three times a year, especially during the wet months, when most other orchids are out of bloom. This orchid responds readily to cultivation but resents too much root disturbance. When re-potting becomes necessary it must be done but provision should be made for the plant to remain undisturbed in its new receptacle for about two years.

Well decomposed leaf-mould should form two thirds of the compost, the remainder being cattle manure mixed with charcoal and a handful of finely crushed crocks. The drainage should be

carefully adjusted as the plant requires copious supplies of water when in full growth. A few pieces of sun-baked cowdung of the size of marbles, sparsely placed over the drainage will be of benefit at a later stage when the roots come in contact with these: but this should not be overdone.

During active growth or when the plant is about to flower a little liquid manure (cowdung dissolved in water) once a week will enable the plant to produce better blooms. This application should cease as soon as the flowers open so as to enable them to remain for a longer period.

After potting, the plant may be placed in the shade until new shoots appear when it may be shifted into the open.

At low elevations it will thrive in a shady spot or in the verandah, but it prefers a warm, dry atmosphere.

FROGEYE DISEASE OF TOBACCO*

A FUNGUS DISEASE

A fungus is a primitive type of organism that is included by scientists in the plant kingdom. Mushrooms and common moulds are well known fungi. Fungi live principally on other living plants, or on dead matter such as decaying parts of plants or plant products, and the soil. Some cause diseases in man; other attack plants, their feeding roots, or threads penetrating the stems, fruits and leaves, and in the majority of cases causing the death of the invaded portions.

The Frogeye fungus is a parasite on tobacco leaves. Its feeding threads kill small portions of the plant tissues, and after a few days the attacked areas turn brown and are visible as spots. The centres of the spots may become bleached, giving the typical Frogeye appearance. When favourable conditions occur, the fungus grows out from the surface of the spot and produces numerous spores which function like seeds when they come in contact with tobacco leaves, in that they are capable of growing and causing other spots.

The appearance of the spot varies with climate, and growth and variety of the plant, but is distinguished from those caused by other diseases by the presence of clusters of characteristic, dark threads bearing long, thin, light-coloured spores. The spores are of various lengths, approximately 300 of average size measuring one inch, presuming they are laid end to end.

The disease attacks plants at any stage of growth, especially when they are maturing in the field. Thousands of spores are produced on leaf-spots and on dead, diseased leaves. The diseased areas are at first a lighter shade of green than the healthy leaf tissue, and later appear as small, brown spots about the size of a pin-prick. As the disease extends, the colour of the affected area changes to brown, and the central portions usually appear bleached, the latter characteristic being more marked during dry periods. Under dry conditions, the spots tend to become relatively large, and to have a clearly defined margin.

The enlargement of spots is partially restricted by the large veins of the leaf, but small veins are readily attacked and killed. This is followed by yellowing of the leaf margins, and more especially the leaf tip, thus resulting in a prematurely ripened appearance. The midrib of the leaf and the large lateral veins are attacked on their upper or lower surface, and the leaf tissue beyond the attacked area turns yellow, later brown, and then dies. Spots often join together and kill large areas of leaf. Such badly spotted leaf is unsuitable for manufacture into smoking tobacco.

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* By A. V. Hill, B. Agr. Sc., Plant Pathologist, Australian Tobacco Investigation Extracted from Australian Tobacco Investigation Pamphlet, No. 2, Sept. 1933.

As the leaves mature from the base of the plant towards the top the disease spreads, until at last even the seed capsules may be attacked. Spores may be produced on both the upper and lower surfaces of the leaves. The fungus remains alive in dead diseased leaves, and continues to produce large numbers of spores (seeds) when climatic conditions are favourable.

The majority of plant diseases tend to be cumulative from year to year under favourable conditions, and this apparently holds true for Frogeye. The comparative freedom from disease of the early crops of 1921-32 was probably due to the limited occurrence of the causal organism at that time. Subsequent spread in the later crops resulted in wide distribution of diseased leaf material and spores throughout the district, with the result that seedlings and field crops were infected in their early stages of growth during the present season. The early and mid-season crops which were well grown and maturing during February were seriously diseased, whereas some of the later crops remained comparatively healthy.

CONDITIONS FAVOURING THE DISEASE

The conditions favouring the disease may be briefly considered under the following headings:—

A—Climatic conditions.

1. Temperature.
2. Rainfall.

B—Cultural practices.

1. Preparation and care of seedbeds.
2. Spacing of transplants.
3. Soil conditions.
4. Delayed ripening and harvesting.
5. Curing practice.

A.—CLIMATIC CONDITIONS

Climate and weather conditions are important factors governing the distribution and economic cultivation of plants.

Climatic factors have an even more marked influence on plant diseases, as the organisms that cause them are usually more susceptible to extremes of temperature and moisture than the plants on which they live.

The occurrence and destructiveness of Frogeye is determined almost altogether by climatic conditions. Under favourable weather conditions the disease becomes epidemic, and, on the contrary, its spread is checked by unfavourable weather. The disease is most severe on well-grown crops during periods of wet weather. Once established in the field, rains or heavy dews provide conditions suitable for its wider spread.

1. *Temperature.*—Frogeye leafspot occurs in areas where high temperature prevails through the day and night during the growing season. The occurrence of such conditions, over a number of months, allows time for the organism to produce many generations of spores from a few spots on the lower leaves. The spores serve to spread the disease throughout the crop. When tobacco is grown under relatively high temperature conditions, as is the case in the Dutch East Indies, Rhodesia, Nyasaland, and

Queensland, Frogeye is serious in some seasons. In contrast with this, it has not been reported from the relatively cooler and drier districts of New South Wales and Victoria, where tobacco has been grown for about 100 years.

2. *Rainfall.*—When the temperature is favourable, protracted periods of wet weather are conducive to the spread of the disease, for like seeds, the spores must be kept moist if they are to germinate and infect the leaf. The spores ordinarily germinate in two hours, consequently the leaves are readily infected if they remain moist for longer than that time. In addition, it must be borne in mind that heavy dews or protracted periods of rainy weather provide conditions suitable for the production of spores.

Rain is also an important agent in spreading the disease, because the spores are splashed for considerable distances by drops of water. One of the obvious effects of splashing can be readily seen by examining the under surface of the lower leaves of plants. They usually retain a considerable amount of soil, and, as a result, are called sand leaves.

An examination of the daily rainfall records for Mareeba over a number of years, shows that periods of showery weather may be expected in many seasons, and that such periods most commonly occur towards the latter end of January and during the early part of February. The occurrence of favourable climatic conditions at the most susceptible stage of growth, which is about the topping stage, will materially assist the spread of the disease. The simultaneous occurrence of high temperature and high humidity over a period of weeks provides optimal conditions for the development and spread of the disease.

When the plants are in the seedling stage, climatic factors may be modified to some extent by covering the seedbeds, and by adopting means to reduce temperature humidity and soil moisture. Such measures also assist in the control of downy mildew and damping-off fungi. It is sometimes difficult, under climatic conditions at Mareeba, to produce hardy, healthy seedlings. Furthermore, unfavourable conditions at transplanting time encourage the development of diseases which may be present in the seedlings or in the surrounding soil.

B.—CULTURAL PRACTICES

1. *Seedbeds.*—Poorly-drained seedbeds situated in low-lying localities are more subject to disease than well-drained and well-ventilated beds in a sunny position. Ventilation lowers the temperature and the atmospheric humidity, the latter being especially necessary and most difficult to accomplish during periods of wet weather. Once the disease is established in a seedbed, practically every plant becomes infected if the conditions are favourable. Seedlings should be carefully thinned out, that they may have ample room for normal growth. The soil should be provided with sufficient fertilizer to maintain good growth, and, if necessary, additional fertilizer may be dissolved in water and applied with the watering-can.

2. *Spacing of Transplants.*—More disease was noticed among well-grown plants closely spaced in the rows than in lower and more open crops. The more open and low-grown crops allow freer movement of air, and tend to lessen splashing of spores from plant to plant. The plants and soil also dry more quickly.

3. *Soil Conditions.*—Badly-drained fields are conducive to Frogeye and other diseases. Water-logged soils check plant growth, cause the leaves to die, and provide conditions that are favourable to an epidemic of leaf-spot. Natural surface drainage and ridging does not prevent seepage water from damaging and even killing the crop. Many crops grown on ridges with a good, natural slope were killed by seepage of water from higher areas. Adequate drainage, recommended during the past three years by experts, will be necessary wherever heavy rainfalls occur.

Lack of drainage of fields was partly responsible for poor crops in the Mareeba district during the 1933 season.

4. *Delayed Ripening and Harvesting.*—As Frogeye is associated with maturity of the leaf, any factor which checks growth or causes ripening, also encourages, to some extent, the spread of the disease. Thus, a check in growth caused by excessively wet conditions, or premature ripening of the leaf, which may be due to a number of unfavourable factors, increases the length of time during which infection may take place. Delay in harvesting the lower leaves allows many more spores to be produced on the spots, and the disease is therefore enabled to spread more rapidly. It follows that it is better to have a small area of tobacco well cared for, than a large area neglected from transplanting to harvest time.

5. *Curing.*—Growth of the fungus within the leaf tissue is favoured by the conditions of temperature and humidity during the early stages of the curing, but instead of the attacked areas becoming at first light brown and then white, as happens under field conditions, they are of a dull, dark-brown colour. This type is known as "Black Barn spot". The discoloration of bright tobacco leaf spoils its appearance, and reduces its value considerably. If the leaf is badly attacked, the spotted areas coalescing, the amount of dead tissue present may lead to the leaf being graded as scrap. Such leaf is very brittle, does not condition properly, and breaks into fragments during manufacture. Leaves spotted at harvest time are not likely to be of much value unless they possess good body and fair texture.

The amount of barn spot depends to some extent on the length of time taken to colour the leaves, those which colour quickly usually having the barn spot than others requiring several days. The results of several experiments show that barn spot infection does not normally occur during curing of the leaf, therefore diseased leaves do not infect healthy leaves in the barn. Experiments also demonstrate that the first signs of disease spots usually appear six or more days after the leaf is inoculated, and a definite brown spot develops in seven or more days. When leaves that are already infected in the field some days previous to harvesting are hung in the barn, the conditions during early curing merely accelerate fungus growth, and the diseased areas become dark in colour.

Since the disease is favoured by high humidity, the lowest humidity compatible with good curing practice will help to reduce the amount of barn spot.

SOURCES OF SEEDBED INFECTION

1. SEED

Plant diseases of all kinds have to provide some means of surviving from one season to another, or else they die out. If a disease becomes associated with the seed, e.g., bunt of wheat, it remains with its host and is ready to begin growing when the seed germinates.

Many important tobacco diseases first appear in the seedbed as a result of using contaminated seed, and therefore the provision of healthy seed is a pre-requisite for the raising of healthy seedlings. In a seedbed, diseases are confined to a few square yards, but diseased transplants are distributed over, and can infect, acres of land, and may, as a consequence, make the land unfit for profitable tobacco culture for some years.

The widespread occurrence of Frogeye in the seedbeds in the Mareeba district suggested that it was associated in some way with the seed. Outbreaks of the disease occurred in widely-separated farmers' seedbeds, and in many cases the only logical explanation was that the seed was the source of infection. This possibility received further support when tobacco capsules, bearing typical Frogeye spots, were found in a farmer's field in late February. From that time until the end of April, the disease was always readily observable on seedbeds maturing in the field. On numerous farms where seed capsules were being left for the next year's supply of seed, examination was made as opportunity offered, and in practically every case a large percentage of the capsules was diseased. In many cases, the leaflets present among the seed capsules showed typical Frogeye spots.

Diseased seed capsules were collected from four different farms, and were later used in very careful experiments, which showed that in each case a number of seedlings from such seeds were attacked by the disease at an early age, while seedlings from healthy seed were not diseased.

Microscopic examination showed that Frogeye spores were present in the seed samples, either unattacked, or on broken bits of capsules mixed with the seed. On many occasions a crop of spores was found on diseased capsules.

2. SOIL AND TOBACCO DEBRIS

The disease may be carried over from season to season by diseased debris with the seed, and also in the soil. The length of life of the organism in the soil has not yet been determined, but it probably survives for some years.

Several diseased leaves forwarded to the research laboratories at Canberra in May, 1932, were dried, ground up some time afterwards, and placed on tobacco seedlings growing in the glasshouse during November. Frogeye leaf spots occurred on the plants two weeks later, thereby showing that the organism had survived for five months in association with the dried tobacco leaves.

Experimental work at Mareeba demonstrated that the fungus survived in soil in an area where diseased leaves had been strung on to sticks during the curing season, some nine or ten months previously. Other experiments showed that it was present in soil on which diseased seedlings

had been grown, and when diseased dead leaves were added to the surface soil, a large percentage of plants grown on that soil became diseased. It is apparent from what has been said, that soil on which diseased plants have been previously grown, or soil which has diseased tobacco scraps present in it, or spores from diseased plants grown during the same or other seasons, is a source of seedbed infection.

An examination of diseased seedlings and plants in the field shows that the lower leaves bear large crops of spores which infect the surrounding soil, or remain associated with the diseased leaf.

The extent to which soils of diseased fields are a source of infection in the succeeding seasons is yet unknown, but experimental evidence shows that plants on soil on which tobacco was not previously grown remain free from disease much longer than plants in adjoining fields on which a crop of diseased plants was grown during the previous season.

Tobacco Scraps.—The organism survives in dead diseased tobacco leaves in the field and even in flue-cured diseased leaves. Flue curing of diseased leaves does not, in all cases, kill the organism causing Frogeye. Scraps of diseased tobacco leaves, *whether previously flue-cured or not*, may therefore cause the disease in nearby seedbeds and fields, or in areas to which they may accidentally be transported by implements, animals, wind or other agencies. Many fungal spores remain alive for long periods under dry conditions, and therefore the rainless winter months at Mareeba may favour the survival of the disease in the soil or in diseased leaves.

3. OVERWINTERING PLANTS

Although at Mareeba there is an almost complete absence of useful rain during the long, dry season, and the soil becomes very dry, some tobacco plants remain alive until the following wet season and then make new growth. Frogeye was present on a number of such plants examined in different areas, both the dead leaves and the new growth being infected. The dead, diseased areas on leaves of the previous season produced spores which were blown or splashed on to the new leaves, infection occurred, and Frogeye was in that way established for another season.

Overwintering plants and the continuous growth of tobacco throughout the year are a menace to the industry, because by these means, diseases and pests survive from season to season.

The "Diseases in Plants Acts" of Queensland provide, *inter alia*—

That every occupier or owner of land used in the growing of tobacco plants shall uproot, and when practicable, destroy plants by burning, within one month after the completion of the harvesting of the tobacco leaf. Every paddock shall be treated in the above manner, and where there have been plantings at separate intervals in different parts of one area, similar action must be taken after harvesting of the leaf from each separate planting.

This act is in the best interest of growers themselves. After harvesting, a vigorous effort should be made to destroy all volunteer plants throughout the district, thus assisting to reduce the incidence of diseases and pests. This objective will be materially assisted by eradication of all tobacco plants throughout the district, for some months each year.

From many points of view, the practice of throwing the old stalks into river and creek beds is most objectionable. Seedbeds are usually situated along the banks of waterways, and therefore the organisms surviving on old stalks may cause outbreaks of disease wherever the material may happen to be transported by water or other agencies. Seeds, which may carry disease, are often present in the capsules on old stalks, and may become detached and distributed by water along the river banks, thus establishing wild tobacco plants carrying diseases and insect pests. Such plants may be seen growing along the rivers and creeks of the Mareeba district at certain times of the year.

A better means of disposal of old stalks is to pile them into heaps and burn them, but they should not be used as fuel for sterilizing the seedbed site, because the accumulation of stalks at one place results in the concentration of scraps of diseased leaf and spores in the area fringing the sterilized soil, and this material is readily carried or blown on to the seedlings.

CONTROL MEASURES

1. SEED

As guaranteed clean seed is not always readily available to farmers, and as the use of diseased seed may result in diseased crops, some experiments involving seed sterilizjation were performed. A.1 per cent. solution of silver nitrate is a most effective disinfectant as it destroys bacteria and fungal spores, and does not harm the seed when used correctly.

Samples of diseased seed obtained from various farms, as well as other lots which were deliberately mixed with diseased parts of plants, were treated with silver nitrate solution. In every case the plants grown from the treated seed were free from disease, provided they were protected from chance infection from outside sources, such as infected soil and diseased plants.

As the disease is present on the outside of capsules in the field, these parts should not be mixed with seed. Contamination may be avoided, to a great extent, by breaking the tips from the dried capsules and allowing the seed to fall out, rather than by threshing in the usual manner. If home-grown seed is used, it is practically always necessary to disinfect it with silver nitrate. The following procedure should be followed:

(1) Nine grains of silver nitrate crystals should be dissolved in one pint of water. The crystals rapidly deteriorate under certain circumstances and should therefore be obtained from the chemist as required. The solution should be made in a glass, earthenware, or wooden vessel, using distilled water or freshly collected rain water, and used immediately. *Silver nitrate taken internally is a deadly poison and should therefore be handled with care.*

(2) The seed should be tied in a bag of some open textured cloth such as butter muslin, and allowed to soak in the silver nitrate solution for exactly 15 minutes. It should be stirred to ensure that all the seed is thoroughly wetted.

(3) After soaking in the silver nitrate solution for 15 minutes, the bag with the seed in it should be washed for 10 minutes in about six changes of clean water.

(4) The seed should be spread out and dried at ordinary room temperature before sowing, taking care that it does not come in contact with diseased material during or after drying, as such contact would defeat the purpose of sterilization.

2. SOIL

If clean seed is sown in soil free from disease, healthy seedlings will be produced if they are protected from other sources of infection. Sterilization of seedbed soil is necessary, under Mareeba conditions, for the control of the widespread damping-off diseases. This treatment also protects seedlings from Frogeye, because it destroys the organism if the latter is present in the soil. The seedbeds should be so situated that soil from fields on which diseased crops have been grown, or from the vicinity of barns and bulksheds, does not come in contact with the seedlings. It is wise practice not to replant the same fields to tobacco in successive years, because diseases tend to accumulate in the soil and, therefore, the plants become infected from that source. As most farmers have a large area of land suitable for tobacco, the use of new land is practicable. This would help to reduce the occurrence of the disease and also tend to improvement in the quality of the crop.

3. SPRAYS

Bordeaux mixture has been recommended for many years as a control for diseases similar to Frogeye. During the 1932-33 season at Mareeba, four series of experiments involving a large number of seedbeds were used to test the efficacy of Bordeaux spray. Spraying was done during the wet season, when Frogeye was most serious in the seedbeds and field. Wherever Bordeaux was used, the disease was kept in check, and particularly was this so when spraying was begun before the disease made its appearance in the seedbeds. As previous experience showed that 4-4-40 Bordeaux mixture was likely to injure delicate seedlings, the strength was reduced to 2-2-40, and spraying was done every five days. The sprayed plots were practically free from disease, and the seedlings were more vigorous and healthy.

Directions for the preparation of 2-2-40 Bordeaux mixture—

(1) Dissolve 1 pound copper sulphate crystals in 1 gallon of water. This is most readily accomplished by suspending the crystals in a muslin bag in water overnight. Use wooden vessels if possible, as iron or steel vessels are attacked by copper compounds.

(2) In another vessel slake 1 pound of freshly burnt stone lime, then add sufficient water to make 1 gallon. It is best to strain the milk of lime solution through butter muslin before diluting further, because any coarse particles present will tend to block the nozzle of the spray pump.

(3) Make each of the above solutions up to 10 gallons and pour both into a third barrel at the same time. If only two vessels are available, pour the diluted copper sulphate solution into the diluted milk of lime solution, stirring vigorously all the time. This will make 20 gallons of spray, and will be sufficient for approximately 300 square yards of seedbeds. The quantity of spray mixture required will vary with the size of the plants, as they must be thoroughly sprayed.

Bordeaux mixture should be used immediately after it is made. Before using, it should be tested by holding a polished knife blade in the mixture for a few seconds. If no copper is deposited on it, the mixture is safe for use, otherwise more lime should be added and the test repeated.

Bordeaux mixture may be combined with lead arsenate or paris green to protect the seedlings against insects.

4. PRIMING

As the disease is commonly more serious on leaves approaching maturity, and as spores are produced in large numbers on mature, or dead, diseased leaves, the operation of priming, which involves the removal of such leaves, greatly reduces the number of spores present and the possibility of future infection in the field. Experiments show that early priming is essential, the aim being to eliminate the diseased, lower leaves before the valuable, middle leaves become infected. This operation must be carried out with discretion, because too severe priming will check growth, and too little will not control the disease sufficiently to make it worth while. The first priming should be done when the plants are only a few inches high. The plants may be primed two or three times before leaves of any commercial value are obtained. Later primings may be in the nature of preliminary harvestings. As many as six or seven may be necessary in some seasons, the discarded leaves being removed from the field and buried or burnt to prevent further spread of the disease by spores, which are produced on them if they are left on the ground or between the rows of tobacco plants.

The priming will not eliminate the disease altogether, but will check its progress in the field, and make possible the harvesting of saleable leaf.

5. HARVESTING

Since the disease is associated with maturity of the leaf, every effort should be made to harvest the leaves as they ripen. The longer an infected leaf is left on a plant, the greater will be the production of Frogeye spores, which will in turn serve to spread the disease to previously healthy leaves. By attacking leaf veins and midribs, the disease may cause yellowing and death of the tissues beyond the attacked area, but such leaf is not mature, and will not cure satisfactorily.

In Mareeba, many leaves were observed in which the tips of margins were dead and the central portion yellowed, while the butt was green. In some cases this was due to the disease, but more generally to unfavourable seasonal and soil conditions which prevented normal ripening.

After harvesting is completed the plants should be eradicated and disposed of as directed in previous paragraphs.

Species of the plant kingdom, which cause disease in our crops, may be considered as being similar to weeds. The most practical method of controlling the spread of weeds is to eradicate them before they have an opportunity to seed. The old adage "one year's seeding, means many years' weeding", applies equally well to plant diseases, including Frogeye. This disease must be checked from the time of its first appearance in seedbeds and fields, or the spore production later in the season will be so great that control will be impracticable.

PHILIPPINE RICE-MILL PRODUCTS WITH PARTICULAR REFERENCE TO THE NUTRITIVE VALUE AND PRESERVATION OF RICE BRAN*

RICE serves as the principal food for people of the Far Eastern countries. In the Philippines the diet of the masses consists largely of rice and is more or less deficient in fats, proteins, and vitamins. This investigation of Philippine rice-mill products, particularly rice bran, was undertaken with the idea of endeavouring to supply the present dietary deficiency.

In the Philippine process of milling rice the hull is first removed leaving the kernel which is somewhat colored and commonly called unpolished rice. The unpolished rice does not keep well because, when stored, the fats in it become rancid. Again the unpolished rice becomes infested with insects which destroy the outer mealy layer of the grain. To produce white polished rice, which can be handled without commercial hazard, the rice kernel is passed through a combined scraping and polishing process. This removes the outer portion of the kernel together with the embryo. That portion of the kernel removed during the polishing process is called rice bran or rice polishings.

Rice bran is the most nutritious part of the rice since it contains fats, proteins, and vitamins. The fats in rice bran are about the same as those in peanuts which are considered quite nutritious. The proteins are very similar to meat proteins since they contain in their make-up about the same important amino acids. Rice bran contains vitamin B_1, which prevents beriberi, and vitamin A, which prevents eye afflictions and general ill-health. It also has the antisterility vitamin E.

At present rice bran is very cheap and is used for feeding cattle and poultry. Millers sometimes dilute the bran with rice hulls in order to dispose of the hulls with profit. Bran, which has been adulterated with rice hulls, is not suitable for use as an edible product because the hulls have an irritating effect when taken internally.

Bran flours are considered quite nutritious and are very popular in the United States and other countries. This would naturally suggest the use of rice bran for human consumption, especially since the bran is very much cheaper than flour. Several American teachers informed us recently that some years ago in the Philippine provinces they tried to make a bran flour by mixing rice bran with wheat flour. Although this mixture made very good bread and cakes they discontinued using it because they found it difficult to obtain a regular supply of high-grade bran. Sometimes the bran was fresh and at other times it was not.

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* By Augustus P. West and Aurelio O. Cruz of the Bureau of Science, Manila, in *The Philippine Journal of Science*, Vol. 52, No. 1, Sept., 1933.

The reason that rice bran has not become a popular human food is probably due to the fact that it contains a quantity of vegetable fatty oil (rice oil). When the rice bran is stored the oil becomes rancid and the bran acquires a disagreeable taste. Millers often pile fresh bran on top of stale bran. To be sure of getting fresh bran one should really go to the mill and take the bran as it comes fresh from the polisher.

The decomposition of the fatty oil in rice bran is due to the action of moisture in the presence of vegetable tissue which contains fat-splitting enzymes. We found that rancidity may be prevented by heating the fresh bran at a temperature of about 105°C., for three hours and storing it in moisture-proof containers which preserve the bran and prevent access of insects. Heating the bran removes moisture and stops the destructive action of enzymes. This prevents decomposition and subsequent rancidity of the fatty oil contained in the bran. The heating also destroys any mold spores, insects, or insect eggs which may be in the bran but does not affect the vitamins.

Bran treated in this manner is slightly darker in color than the fresh, raw bran but it has a pleasanter and sweeter odor and flavor than the raw bran. It does not become moldy or rancid; in fact, it may be kept in a fresh condition for a considerable length of time without any appreciable deterioration.

In preparing rice bran for storage it is advisable to use a specially constructed cooker containing a stirrer. Stirring the bran while heating facilitates the removal of moisture. In outlying districts where proper cooking facilities are not available the bran may be heated cautiously in a frying pan over a low fire. The bran should be stirred and the heating continued for perhaps an hour until it turns slightly darker in color. After heating, the bran should then be placed in a can or glass jar which may be closed tightly to prevent access of moisture. Bran, thus prepared, keeps for about a week or more.

Miss Maria Y. Orosa, of the Bureau of Science, has prepared excellent cakes, cookies, and bread from mixtures of wheat flour and rice bran. She used fresh bran and also bran which had been heated and stored for two months. The results were the same in each case. These bakery products were very satisfactory in texture and quite tasty.

For people who do not fancy the natural flavor of rice bran this may be toned down considerably by diluting the bran with wheat flour. A mixture of wheat flour (3 parts) and rice bran (1 part) makes a good combination for bakery products such as bread and cakes. When used alone rice bran, lacking gluten, does not make bread which will rise. The addition of wheat flour serves not only to dilute the bran but also to supply the gluten necessary for making bread.

The bran flavor may be still further neutralized or entirely disguised by using other characteristic flavors, such as ginger, cinnamon, or chocolate. Bran cookies made with these flavors are very tasty and since they contain vitamins they are quite nutritious.

In the Philippines beriberi is a very common and fatal disease among the poorer classes who live on a diet that consists principally of polished rice and is deficient in vitamin B_1. For a number of years the Bureau of

Science has been making a standard extract of rice bran (tikitiki extract) which contains vitamin B_1. This extract is widely used for curng or preventing beriberi. It has been estimated that for adults approximately 30 grams of high-grade rice bran contain about enough of the antineuritic vitamin B_1 for their daily requirements as a preventative of beriberi. This is about equivalent to 11 level (not heaping) teaspoonfuls of bran or approximately 2 cubic centimeters of standard rice-bran extract. More than 111,000 tons of fine rice bran are produced annually, in the Philippines, as a rice-mill by-product. As a preventative of beriberi this amount is about sufficient for all the people who need the bran for its medicinal valuc and also for others who might benefit by using it.

In a very few localities in the Philippines the people have for years been used to eating a kind of cake made from a mixture containing some fresh rice bran. If this use of rice bran as a human food could be popularized and the people all over the Islands become accustomed to eating bakery products or other foods containing the rice bran then deaths from beriberi would be a rarity. It would not be necessary for the poorer classes to take extract of rice bran as a preventative or cure for beriberi.

Rice bran produced at present in the Philippines is not taken care of properly and much of it is allowed to spoil and is wasted. By utilizing this by-product of the rice mills as a food the health of the people would be generally improved. They would be getting not only vitamin B_1, which prevents beriberi, but also vitamins A and E and proteins similar to meat proteins. The children would be healthy and vigorous and would not appear to be improperly nourished. Moreover, by using a domestic by-product the Filipinos would be developing the natural resources of their own country and the importation of rice and other foodstuffs from foreign countries would be greatly diminished.

RICE CULTIVATION

There are many varieties of rice grown in the Philippines. According to habitat, method of cultivation, and general properties these numerous varieties are usually classified in terms such as upland and lowland rice, glutinous and non-glutinous. They are identified by certain trade names, such as Macan 1 (official No. 527), which are recorded as permanent numbers in the Philippine Bureau of Plant Industry. The different varieties are distinguished by their principal physical characteristics such as length, width, and thickness of the grain, the color of the hull and tips, flavor, and other properties. In general the late-maturing varieties give a larger yield per hectare than the early-maturing varieties.

Various methods are used for cultivating rice in the Philippines. One very common practice is to plant the rice in seed beds and later transplant the seedlings to the rice paddy (field). Chemical changes which occur during the ripening of rice grains have been studied by Tadokoro and Abe. In their report they refer to previous work along this line.

When the growing rice reaches maturity it is cut and stacked in the field in well-ventilated shocks and allowed to remain there about a month in order to cure the grain. Changes, not well understood, take place during the curing process. If the grain is not cured thoroughly, before threshing, it heats during storage and the moisture content increases. As a result it is likely to spoil.

RICE STRAW

Rice straw is obtained as a by-product in threshing rice. In the Philippines rice straw is used as packing material, bedding for cattle, fuel in finishing pottery, for making mats, brooms, sandals, and for various other purposes. Rice straw serves as good bedding for the cultivation of edible mushrooms.

Experiments on the use of Philippine rice straw as a raw material for the manufacture of paper were carried out by Reyes and Cruz. They estimate that enough rice straw is produced in Bulacan Province alone to supply a 10-ton paper mill.

Philippine rice straw makes a very good tissue paper. Reyes and Cruz found that paper made from Philippine cogon grass is stronger than that made from rice straw. However, rice straw requires for digestion about one-third as much caustic soda as cogon and is easier to bleach. In the Philippines where chemicals are expensive this is a decided advantage. Again, since rice straw is a by-product in threshing rice no extra labor of cutting the straw is required as is necessary in the case of cogon grass.

PHILIPPINE PROCESS OF MILLING RICE

There is quite a difference in the appearance and arrangement of machinery in the numerous Philippine rice mills. Some mills are more or less home-made, while others have very modern equipment. All of these mills, however, carry on the same operations and produce polished rice with rice hulls and rice bran as the principal by-products.

The milling of rice consists essentially in gradually breaking up the rice grain (paddy or unhulled rice) into products which are separated by a number of large shaking sieves.

In the Philippine process of milling rice the grain (paddy rice) is first passed through a cleaning sieve that removes trash and straw. The paddy rice is then carried to the rice huller. This breaks the hulls which inclose the rice kernel (unpolished rice). Some paddy rice grains usually pass through the rice huller without the hulls getting broken. The mixture (hulls, unpolished rice, and paddy rice) emerging from the rice huller is then sieved to remove tips, very finely broken grain, and small pieces of hulls. The mixture is then carried forward to the blower which is the next unit in the process. This is a special compartment. It contains a fan which blows the hulls out into an exit tube where the hulls are usually carried to the boiler to be used as fuel. The unpolihsed rice containing some paddy rice then drops to the separator sieve. This separates the unpolished rice from the paddy rice which is carried back to the rice huller.

The unpolished rice is next taken to the polisher. Some mills have two polishers. In passing through the polisher the surface of the grain is scraped with an abrasive thus removing the seed coat together with some of the outer portion of the rice kernel. The germ of the rice grain, which is rich in soil, is dislodged and also goes with the polishings (bran). In addition to the scraping procedure the grain is also polished with rubbers in passing through the polisher. At the bottom of the rice polisher there are two exit tubes. The white polished rice emerges from

the polisher through one of these exit tubes and the rice bran through the other. The white polished rice is next sieved to remove the very small broken grain (binlid).

The milling of rice is really a very clean process. From the time the paddy rice enters the mill until the polished rice and rice bran emerge from the mill these rice-mill products are not handled by laborers. The whole process is carried on automatically by machinery.

For power many mills have a steam engine and use the rice hulls as fuel to heat the boiler. Recently, however, some mills have introduced oil-burning engines.

In addition to the power house the four other essential parts of a rice mill are the rice huller, the blower, the separator, and the polisher. The rice huller consists of two iron disks. One is placed just above the other and the two are separated by a very small space. Artificial stone covers the lower surface of the top disk and the upper surface of the bottom disk. The top disk remains stationary while the bottom disk revolves. The whole apparatus is arranged so that the distance between the two stone surfaces can be adjusted by means of hand wheels which raise or lower the bottom disk. The paddy rice is poured into the rice huller through a hole in the middle of the top disk and falls on the lower revolving disk which throws it away in all directions. The revolving disk then grinds the grain around and breaks the hulls. The distance between the two disks should be arranged very exactly as otherwise the rice kernel may be crushed or the hulls not well broken. The rice huller is one of the most important parts of a rice mill since upon it depends the quantity of rice obtained from a given amount of whole grain.

The rice polisher is a rather ingenious apparatus. It consists simply of an inverted frustum of a cone set inside of a wire screen. The cone and the screen are inclosed in a cylindrical iron container. Before taking the photograph a portion of the wire screen and a portion of the outside iron container were removed to show the abrasive cone inside. The top and side surface of the cone are covered with an abrasive prepared by mixing small pieces of emery with water glass (sodium silicate). Attached to the inner (cone) side of the wire screen and some distance apart are several vertical rubber strips. The cone, supported by a main shaft, is made to rotate rather rapidly. For a medium-sized cone the rate is about 300 to 400 revolutions per minute. A stream of unpolished rice is allowed to fall on the top of the cone. In descending through the polisher the grain (rice kernel) is whirled around in the space between the cone and the screen. The abrasive on the cone scrapes the surface of the grain, while the rubber strips, on the screen, polish the grain. The white grain, scraped and polished, emerges from the opening at the bottom of the apparatus, while the bulk of the scrapings (polishings or bran) passes through the wire screen. The bran which thus accumulates outside the screen is pushed, by a rotating slide, to an exit tube where it falls out.

A tube, placed at the side of the polisher, connects the space outside the screen with an exhaust fan. The fan draws a current of air through the screen. This air current prevents the polished rice from getting too hot and also removes most of the very fine bran dust that tends to adhere to the polished rice.

The degree of scraping the grain depends upon the adjustment of the cone. By lowering the cone the space between the cone and screen is made smaller and the progress of the grain through the polisher is retarded. The grain thus gets a more thorough scraping. By means of adjustment screws the rubber strips on the wire screen may be projected inward toward the cone. This also retards the progress of the grain, giving it a more thorough polishing and scraping.

In removing hulls from the paddy rice (hulling process) some of the rice kernels are broken. These broken kernels are passed through the rice polisher with the whole kernels. When the polished rice is sieved the larger pieces of broken polished rice remain with the unbroken polished rice while the very small pieces (binlid) together with some bran are removed. Small pieces of grain are usually sold as chicken food or used for making starch. Millers usually do not keep an accurate account of this stock which is comparatively small. The small pieces of broken polished rice serve as a good material for fermentation and so this kind of rice (brewer's rice) may be used for making fermented beverages. In Japan the manufacture of saké from rice is an old established industry.

In the Philippines the rice sold in the markets, stores, and tiendas is usually a mixture of the whole and partly broken polished rice. The millers do not ordinarily separate this mixture.

In isolated districts in the Philippines miniature rice mills, commonly known in Tagalog as kiskisan, are sometimes used for milling small amounts of rice. In these mills the separation of bran and hulls is usually not very complete and consequently a low grade of bran, unsuitable for edible purposes, is obtained. In order to ascertain if the grain has been milled properly and the fresh bran is not diluted with hulls the bran should be tested as explained later.

Results in Philippine rice mills.—In milling rice the quantity and quality of the finished product depend upon the method of milling, the efficiency of the mill machinery, the variety of rice milled, and the condition of the rice before milling. During the process of milling some lots of rice break up to a much greater extent than others. The quantity and quality of the polished rice are therefore quite variable. In order to get a product of approximate average grade it is a very common practice in the Philippines to mix different varieties of rice before milling. However, one may occasionally visit a mill when they are running only one variety.

RICE STARCH

Although rice starch is not strictly a rice-mill product it may be well to mention it since it is an important commercial product made from polished rice. Rice contains about 78 per cent. of starch. This is a larger percentage than is contained in any other starchy material, such as wheat, maize, or potatoes. Various authorities give a very good description of the manufacture of starch from rice. According to Thorpe—

The demand for rice starch has grown chiefly because of its suitability for laundry use, and this in turn is due entirely to the fact that the rice starch granule is considerably smaller than that of any other commercial starch. When made with boiling water, too, the resulting mucilage is better adapted for "starching" than other starches.

Rice starch is used commercially for various purposes such as laundering, preparing foods, making paste, and making medicinal tablets. It is also employed extensively in the cosmetic industry for making face powders. In addition to the perfume, the principal characteristics of a good face powder are color, texture, and perfect adherence to the skin. The latter qualities impart the appearance and finish. According to Poucher, the peachlike finish given to the skin by face powders is best obtained by the use of rice starch. Other starches, especially maize, are employed in cheaper powders. The particles of rice starch are much finer than those of any other cereal and consequently there is a distinct preference for rice powders. Parisian manufacturers of cosmetics rate these powders very highly and in comparing the qualities of rice powder with other powders they find the rice powder to be by far the least harmful to the skin and much smoother.

RICE HULLS

In milling rice the hulls are obtained as a by-product. They are light in weight, neutral in odor and have a slow combustibility. They are used for packing hygroscopic materials to prevent moisture absorption; filtering and percolating; for insulation, making insect powder, and various other purposes.

In the Philippines the rice hulls are generally used as fuel in the rice mills. They are also employed in hatching duck eggs and in burning wood for charcoal.

Since the ash consists principally of silica the hulls have a very low nutritive value. It is generally believed that the hulls have an irritating effect upon the stomach and intestines of animals.

On account of their very high silica content the ashes of rice hulls, when finely powdered, serve as a good polishing powder. They should also be useful for making polishing pastes and scouring soaps.

Rice hulls have been found to be useful for making an edible rice cellulose. Harding states:

A recent advance in food technology is the development of a process of recovery of an edible cellulose from the hulls of rice and other cereals. Cellulose is a natural constituent of practically all vegetable foods and is really an essential dietary constituent. By adding bulk and roughage to the intestinal contents normal elimination is promoted and constipation largely prevented.

In the development of a new ready-to-serve breakfast food milled rice was found to be the most desirable cereal base. Because of the low cellulose content of milled rice it was decided to reinforce the roughage content of the finished cereal by additions of a pure cellulose of suitable physical form. It was found that a satisfactory pure edible cellulose could be prepared from the hull of the rice, thus making the breakfast food an all-rice product. The cellulose of the hull is first isolated in a semifibrous form by a strong soda cook. A hydration treatment then reduces it to the proper physical form for use as an edible material.

A large plant for the production of this new form of pure cellulose has been in operation for some time. It is located at Lake Charles, Louisiana, adjacent to the largest rice mill in the world.

Rice cellulose as prepared for food roughage is a light, somewhat fluffy, fine mealy material. It has a light cream color, but is easily bleached white if desired. It is odorless and tasteless. It has a mealy feel in the mouth, and although not intended to be eaten straight, when well moistened with saliva, can be swallowed without difficulty or irritation. Its ash content has been reduced to 1·0 per cent. or less, although the original raw material contains about 18 per cent. of ash that is largely insoluble silica. The washed product from the alkaline digestion may run as high as 99 per cent. alpha-cellulose. In the finished product a part of the original compound or normal celluloses has been converted to simpler hydrated celluloses; but the freedom from impurities of non-cellulosic character entitles it to be called a practically pure cellulose.

POLISHED AND UNPOLISHED RICE

After passing the paddy (unhulled) rice through the rice huller to remove the hulls the unpolished (hulled) rice then goes through the polisher. There are several reasons for polishing rice. Polished rice has a very clean, white, and tasty appearance, whereas the unpolished rice is slightly colored and is not so attractive. Polished rice has much better keeping qualities than unpolished rice. The unpolished rice loses its flavour in a tropical climate because the fats in it become rancid. Again the unpolished rice has a tendency to get moldy and become infested with weevils and other insects, which destroy the outer mealy layer of the grain. This is the reason why the wholesale rice dealers are reluctant to handle unpolished rice. Polished rice can be handled without commercial hazard.

The unpolished rice, which still retains the seed coat and oily germ, contains somewhat more fat, protein, ash, and crude fiber than the polished rice. The polished rice, however, contains more starchy material (carbohydrates).

The effects of living on a diet composed largely of polished (highly milled) rice or unpolished (undermilled) rice are stated very clearly by Vedder and Feliciano:

Although medical authorities still differ with regard to a number of details concerning the etiology of beriberi, there is a very general consensus of opinion to the effect that beriberi is a deficiency disease, produced whenever, in the absence of an adequate mixed diet, highly milled rice is used as the main food staple, and that the disease can be prevented by the substitution of a sufficiently undermilled rice. The most striking illustration of this fact with which we are familiar is the case of the Philippine Scouts. For a number of years (1902-1909), while they were supplied with the best grade of highly milled rice, beriberi was the most important cause of admission to sick report for these native troops, the incidence often reaching as high as 10 per cent. of the entire number (5,000). In 1910 the substitution of undermilled rice was made. Beriberi at once declined as a cause of admission and at the end of a year, when the substitution had been made universally effective, beriberi was completely eradicated. Since that time undermilled rice only has been furnished, and during all these years beriberi has completely ceased to appear among these troops, although they were living in the midst of a population where beriberi is very common. Similar results have been obtained in a number of civil institutions in the Philippines as well as in other countries.

The reason the unpolished rice is a preventative of beriberi is because it contains the antineuritic vitamin B, which prevents beriberi. During the polishing process, to produce white polished rice, most of the vitamins go with the rice bran which is removed from the grain as a by-product.

Vedder and Feliciano carried out an elaborate investigation to determine a standard for unpolished rice which would prevent beriberi. Samples of unpolished rice from many varieties were analyzed and also fed to pigeons to determine their actual beriberi-producing potentialities. Pigeons were selected because they are even more susceptible to polyneuritis than the human race is to beriberi. As a result of their investigation they suggested, as tentative standards, the following chemical indices for beriberi preventing rice:

Any rice having 1·77 per cent. of phosphorus pentoxide plus fat, but not less than 0·4 per cent. phosphorus pentoxide; or any rice having not less than 0·62 per cent. phosphorus pentoxide; or any rice having not less than 0·50 per cent. phosphorus pentoxide and with at least 75 per cent. of the external layers of the grain remaining.

Vedder and Feliciano also determined the effect of washing unpolished rice and found that for ten samples the average loss in phosphorus pentoxide was 0·25 per cent. Presumably the vitamin content of these rices was similarly reduced. They further state—

Previous writers, including Schüffner and Kuenen and McCarrison and Norris, have shown that prolonged washing or soaking of the rice, prior to cooking, extracts and removes a considerable portion of its vitamin, and that an originally beriberi-preventing rice may be thus converted into a beriberi-producing rice. This is what would be expected, in view of the fact that the antiberiberi vitamin is very freely soluble in water. It is to obviate such difficulties as much as possible that we have recommended such a high standard for a beriberi-preventing rice. A lower standard would undoubtedly suffice if it were not for such factors as excessive washing, pressure cooking, and other procedures that cannot be foreseen; but the standard recommended at least provides a considerable margin of safety.

THE NUTRITIOUS PARTS OF THE RICE GRAIN (EMBRYO AND ALEURONE LAYER)

According to Vedder and Feliciano the antineuritic vitamin B, the fat, and most of the phosphorus of the unpolished rice are undoubtedly contained chiefly in the embryo (germ) and the aleurone layer of the unpolished rice grain.

The aleurone layer is the outermost layer of the endosperm or that part of the rice kernel that lies just beneath the seed coat. The aleurone cells in this layer contain protein granules and oil droplets. These oil droplets as well as those in the embryo comprise the rice oil which may be extracted from the bran. Starch granules in the cells beneath the aleurone layer are recognized by the familiar blue color imparted by an iodine solution. No oil droplets are found in these starch cells beneath the aleurone layer though protein granules are observed near the cell walls. The oily embryo and the aleurone layer are really the most nutritious parts of the rice grain since they contain the vitamins, the fats and also proteins.

During the polishing process the entire seed coat of the unpolished rice is removed. The embryo (germ) is also removed as well as most of the aleurone layer of cells. Polished rice usually contains small portions (remnants) of the oily aleurone layer. The fatty oil contained in these portions of the aleurone layer becomes rancid when the polished rice is stored for some time and as a consequence the polished rice tends to lose its fresh flavor.

The degree of polishing determines how much of the aleurone layer remains with the polished rice. A highly polished rice contains very little of the aleurone layer. As suggested by Vedder and Feliciano and shown by the diagrams of Santos the polishing process removes from the rice grain the most nutritious parts which go with the rice bran (polishings).

RICE BRAN

After the paddy rice is hulled the unpolished (hulled) rice, which remains, is passed through the polisher to get white polished rice. In the Philippines the rice polishings, removed during the polishing process, are commonly called rice bran, tikitiki, or darak. This rice bran (polishings) comprises the seed coat, germ, and most of the outer (aleurone) layer of the rice kernel together with some of the starchy material beneath the aleurone layer. The rice bran contains the most nutritious parts of the rice grain for it has vitamins, fats, proteins, and the phosphorus ingredient, as well as some starchy material (carbohydrate).

Bran with rice hulls.—In making rice-bran (tikitiki) extract we find that a bran which is moisture free and contains at least 20 per cent. fat gives an excellent product, so we have come to regard this kind of bran as one of standard quality.

In our inspection of Philippine rice mills we visited several wh it was customary to mix ground rice hulls with the bran. As the hulls co in very little fat (less than 1 per cent.) this diluted bran would, of course, give a low fat content, less than 20 per cent.

The amount of ground hulls contained in diluted bran may be estimated approximately. Suppose a sample of diluted bran, when analyzed, gives only 15 per cent. fat calculated on a moisture-free basis. How much genuine bran is in the diluted mixture? A sample containing only bran of high quality (100 per cent. standard bran) has at least 20 per cent. fat. The hulls may be considered roughly as having no fat.

Santos has recently made a microscopic study of rice bran. He found that rice hulls, when contained in the bran, may be identified as they present a characteristic appearance under the microscope.

Rice bran suitable for use as an edible product should not contain any rice hulls. The hulls contain about 21 per cent. of ash which consists mostly of silica. As the silica has abrasive properties, quite likely the hulls have an irritating effect upon the stomach and intestines.

In milling rice bran intended for edible purposes the mill should have a very efficient blower which will remove practically all the rice hulls from the unpolished rice. In our investigation of Philippine rice mills we found that most of the mills had very good blowers.

In purchasing bran from a rice mill it is advisable to inspect the unpolished rice before it goes through the polisher. If the grain before polishing contains no hulls then the bran removed from the grain during the polishing process will also be free of hulls unless the bran has been purposely adulterated. The bran should be taken as it comes fresh from the polisher because millers often pile fresh bran on top of stale bran so that bran lying in heaps about the mill is not likely to be very fresh.

Bran from the first polisher contains somewhat more fatty oil than bran from the second polisher. During the second polishing of the grain there is naturally a tendency to remove more of the interior starchy part of the grain beneath the outer oily (aleurone) layer. The fat content of the bran will, of course, vary somewhat according to the degree of polishing. Calculated on a moisture-free basis bran from the first polisher contains over 21 per cent. of fat. Where only one polisher is used the fat content of the bran is 20 per cent. or more.

Rice oil has a rather dark brown color with a greenish tinge. The color is somewhat undesirable because buyers of edible vegetable oils, such as coconut oil, usually prefer an oil which is very light in color.

VITAMINS IN RICE BRAN

Rice bran contains the water-soluble vitamin B, which is the anti-neuritic vitamin that prevents polyneuritis in pigeons and beriberi in humans. The rice oil (fats) in rice bran contains the fat soluble vitamins A and E. When irradiated, the rice oil also contains vitamin D.

Vitamin B_1.—The effects of feeding rice bran to pigeons ill with polyneuritis are clearly shown. A pigeon was fed by Dr. A. J. Hermano, of the Bureau of Science, on a ration deficient in vitamin B_1 until it developed polyneuritis. When given 0·5 gram of rice bran the pigeon recovered in one day and became normal.

Vitamin B_1 appears to be quite resistant to heat. We heated rice bran at a temperature of 105°C. for three hours. Doctor Hermano found that this heated bran cured pigeons of polyneuritis just as easily and quickly as the fresh bran.

McCollum and Simmonds state that Jansen examined unhulled rice which had been stored for 100 years and found the rice had lost little or none of its antiberiberi property (vitamin B_1). From this it appears that the hull serves as an excellent protection for the vitamins contained in the rice kernel. Moreover vitamin B_1, under the proper conditions, has excellent keeping properties.

Kondo and Okamura kept unpolished rice in sealed tin cans for several years and found the rice was not attacked by insects and there was little change in the physical and chemical properties.

Concerning the vitamin B complex Dutcher says:

Considerable work has been done to show that the vitamin B complex may consist of five or more fractions. The existence of the antineuritic fractions, B_1 has been established definitely and vitamin B_2 is recognised as a definite entity. These vitamins are also known, in this country, as B and G respectively. Eddy and co-workers contend that a third factor (B_3) is necessary for growth in pigeons, while Miss Reader of London believes

that there is a fourth fraction of the old B complex which is necessary for normal growth in the rat. Miss Chick, also of London, is of the opinion that she has obtained evidence that a fifth fraction exists which is necessary for rat growth and which differs from B_4 in stability.

Windaus and co-workers have just announced the isolation of the antineuritic fraction (B or B_1) in crystalline form. Using modifications of the methods used by Jansen and Donath, Siedell and Peters, two types of crystalline products were isolated, one as the hydrochloride and one as the picrolonate. He ascribes the tentative formula, $C_{12}H_{17}N_3OS$ to this highly potent crystalline product. This compound was active in daily doses of from 2 to 4 gamma (2/1000 to 4 1000 of milligram). The most potent preparations reported previously were those of Jansen and Donath, which were active in doses of from 7 to 9 gamma daily.

Rice-bran (tikitiki) extract.—For a number of years the Bureau of Science has been making an extract of rice bran (tikitiki extract) which contains vitamin B_1 and is used extensively for the cure of infantile beriberi. During the year 1931, 50,974 bottles of tikitiki extract with a sales value of 35,681·80 pesos were prepared. Of this number 4,087 valued at 2,860·90 pesos were sold and 46,887 bottles with a sales value of 32,820·90 pesos were furnished to the Office of the Public Welfare Commissioner for free distribution.

The present method used by the Bureau of Science for making rice bran (tikitiki) extract is indicated by the following outline:

1. Select a good grade of rice bran. This is ascertained by making an ether extract of the bran to determine the amount of fat it contains. This should be about 20 per cent. calculated on a moisture-free basis. If the fat content is much lower than this it indicates that the bran contains ground rice hulls or other foreign matter which does not contain any fat or vitamins; or perhaps the bran has deteriorated due to attacks of insects.

2. Mix the rice bran (50 kilos) with 25 per cent. ethyl, or grain, alcohol (150 liters) and allow the mixture to stand, with occasional stirring, for twenty-four hours.

Vitamin B_1 is very soluble in water. The alcohol which is added serves to prevent fermentation of the vegetable matter in the bran.

3. Pour off the clear liquid and pass the sediment through the press.

4. Combine the liquids obtained in step 3 and evaporate to a syrupy consistency under 1 centimeter pressure with maximum temperature of 75°C.

5. Add 95 per cent. alcohol to residue in step 4 to precipitate inactive gummy substances.

6. Allow the gummy substances to settle for about twenty-four hours then decant off the supernatant liquid.

7. Evaporate the alcoholic solution with precautions observed in step 4 till the specific gravity of the syrup is brought to 1·32 at 28·5°C., which is about the usual temperature of the factory evaporating room.

8. This syrup is then passed through the supercentrifuge, heated to 80°C., and bottled immediately while hot. After sealing the stoppers with sealing wax the bottles are pasteurized at 62°C., for about a half hour.

This preparation is the finished product which is now ready to be used as a medicine for beriberi.

Mr. F. M. Yenko, who has charge of the tikitiki-extract plant in the Bureau of Science, finds that the yield of tikitiki extract from rice bran varies considerably depending upon the quality of the bran used in making the extract. A sack (50 kilos) of very high-grade bran may yield as much as 75 bottles (50 cubic centimeters each) of standard extract. A sack of low-grade bran, which contains a considerable quantity of broken rice kernels and rice hulls, may give only about 45 bottles. By selecting from a shipment only those sacks which contain bran of good quality rather high average yields of extract may be obtained. During the year 1932 Mr. Yenko obtained an average monthly production of 69 bottles of extract from one sack of bran. At this rate of production the potency of 1 cubic centimeter of extract is about equivalent to that of 14·5 grams of high-grade rice bran.

The Bureau of Science sells a 50-cubic-centimeter bottle of extract for 70 centavos (Philippine currency) or 35 cents (U. S. currency). The mail or freight charges are extra.

Hermano standardized this extract and found that when 0·2 cubic centimeter is added daily to a basal ration deficient in vitamin B_1 the ration then contains sufficient vitamin B_1 to support a growing rat. Pigeons which had contracted polyneuritis were cured in one day when given an aqueous solution containing 0·0175 gram of the pure extract. In these experiments the pigeons were kept in cages which were covered with fine-mesh wire to prevent access of the flies known as *Pseudolyncha maura*. These flies transmit to pigeons a blood disease (*Haemoproteus columbae*) which may become so severe as to prove fatal.

Experiments were also made by Doctor Hermano to determine the relative potency of the standard tikitiki extract as compared with activated clay secured from the Bureau of Chemistry and soils in Washington. This activated clay serves as an international standard for vitamin B_1. It has a concentration such that 10 milligrams are equivalent to one unit of vitamin B_1. A unit is that amount of vitamin B_1 which, when fed as a daily allowance, gives a weekly increase of 3 grams in the weight of an albino rat during an experimental period of four to eight weeks. Experiments in curing pigeons of polyneuritis showed that 10 milligrams of activated clay (1 unit) gave the same results as 17·5 milligrams of standard tikitiki extract.

Vitamin A (fat-soluble) in rice bran.—McCarrison found in unhulled rice vitamin A which prevents eye afflictions. Hermano fed albino rats on a ration deficient in vitamin A until they developed general ill-health and the eye disease known as xerophthalmia. The basal ration was then supplemented daily with 0·2 cubic centimeter of the fatty oil contained in rice bran. After one week the eye disease was cured and in one more week the rats had recovered their health and were again normal. The fatty oil used in these experiments was an ether extract of rice bran. The extract was heated in an air bath at a temperature of 105°C., for three hours to remove traces of ether. Evidently heating the fatty oil did not destroy the vitamin.

Vitamin E (fat-soluble) in rice bran.—Hermano tested the fatty oil contained in rice bran and found it gave positive results for vitamin E (fat-soluble) which prevents sterility. Concerning his experiments he states:

Six pairs of healthy rats were mated in six different cages. They were fed with the basal ration deficient in vitamin E. Three pairs of the rats, 1, 2, 34, 35, 36, and 37, were fed with the basal ration deficient in vitamin E for about three to four months, and no litters were produced. After an interval of time the basal ration was supplemented daily with 0·2 cubic centimeter of the ether extract of crude tikitiki (rice bran). The results of the addition were significant in that these three pairs produced seventeen young. The other three pairs, rats, 3, 4, 25, 26, 27 and 28, continued to be fed with basal ration deficient in vitamin E; and, though they appeared to be healthy and mature, they produced no litters. The ether extract from crude rice bran possesses the anti-sterility property, vitamin E.

Vitamin D in irradiated rice oil.—In making Japanese saké wine and the saké cake that remains as a residue contains some rice oil. Takahashi and Lim extracted the rice oil from saké cake. The unsaponifiable matter in the rice oil was then removed and from this unsaponifiable matter they isolated a crystallized sterol which melted at 137°C. These sterol crystals were then exposed to ultraviolet light (irradiated). Takahashi and Lim found that these irradiated sterol crystals were antirachitic and, when fed to albino rats, could cure and prevent rickets. Evidently the sterol crystals, when irradiated, developed the antirachitic vitamin D.

Rice oil contains about 4 per cent. of unsaponifiable matter which is a comparatively large amount. Since unsaponifiable matter consists largely of sterols it would seem quite likely that vitamin D is either contained in rice oil or may be developed in the oil by irradiation.

Hermano tested rice oil for vitamin D and found it gave negative results. He then exposed the oil for fifteen minutes to ultraviolet light and tested the irradiated oil. Albino rats were fed for about a month on a basal ration deficient in vitamin D until the rats developed symptoms of rickets. The joints in the hind legs became somewhat swollen and the rats moved rather slowly. The basal ration was then supplemented daily with an olive oil solution containing 0·003 gram of irradiated rice oil. After three weeks the rats became quite lively, walked well and the leg swellings disappeared. The rats were then killed and the tibia bones in the hind legs cleaned, treated properly, and photographed. The photographs showed considerable calcification in the bones. Photographs of the tibia bones from rats fed on the same ration, except that cod-liver oil was used in place of rice oil, showed somewhat more calcification. Perhaps if the rice oil had been irradiated somewhat longer it would have given results as good as the cod-liver oil. For when the rice oil was irradiated for periods of only 5 and 10 minutes the results were not as good as when it was irradiated for 15 minutes.

Chicken perosis.—When used in a uniform diet for growing chickens, as pointed out in a note published recently, rice bran appears to be superior to wheat as preventative of perosis (deforming leg weakness) in chickens.

In the fall of 1929 the animal husbandry division of the Bureau of Animal Industry and the departments of poultry and husbandry of several Southern and South western State agricultural experiment stations organized an informal co-operative project for the purpose of comparing, on a weight-for-weight basis, different feeding stuffs when included in a so-called "uniform" diet in growing chickens. During the spring and summer of 1930 the following experiment stations used the "uniform" diet in some of their feeding experiments with the growing chicks, Kansas, Louisiana, New Mexico, Missouri, Texas, the U.S. Poultry Experiment Station, Glendale, Arizona, and the U.S. Animal Husbandry Experiment Farm, Beltsville, Maryland.

Several of the stations reported that when the "uniform" diet was fed to chicks kept in confinement a high percentage of them became afflicted with perosis (deforming leg weakness). One of the writers (W.M.G.), observed, however, that when 10 and 20 per cent. of rice bran replaced equivalent amounts of wheat in the "uniform" diet, no cases of perosis occurred.

Perosis, or deforming leg weakness, in chickens is a condition of dietary origin, in which the legs become deformed in various ways.

The superiority of the rice bran as reported in these experiments is quite likely due to some vitamin contained in it.

Commercial importance of vitamins in rice oil.—Rice oil contains the fat-soluble vitamins A and E; and, when irradiated, vitamin D is developed in the oil. Should the vitamin D content of rice oil be increased, with sufficient irradiation, to that of cod-liver oil then the rice oil may become an important nutritive substance. Possibly it could be used as a substitute for cod-liver oil. Rice oil has a bland, fatty taste and in in this respect the oil is certainly more agreeable to take than cod-liver oil.

In the United States the use of vegetable oils, particularly coconut oil, in making margarine has increased very considerably in recent years. According to Snodgrass:

Since the war the vegetable fats, and in particular coconut oil, have continued to grow in popularity in this country until now the ratio of animal to vegetable fats used in margarine is almost the reverse of what it was before the war. Approximately 60 per cent. of the ingredients are now of vegetable origin, and only 40 per cent. animal fats. Coconut oil is far and away the most important single ingredient. In 1925-26 more of it was used than of all the animal fats together and over a period of several years it has been more important than oleo oil and neutral lard combined. The only other vegetable fat used in appreciable quantities is cottonseed oil.

Coconut oil does not contain the fat-soluble vitamins A, D, and E. Since rice oil contains the fat-soluble vitamins A and E it might serve as an important product for use in the margarine industry as the rice oil would supply the vitamins which are not contained in the coconut oil. Mixtures of coconut and rice oils should make a margarine more like natural butter than when coconut oil alone is used.

In producing rice oil for commercial purposes either bran fresh from the polisher may be used or, as explained later, bran whcih has been heated and properly preserved. The rice oil may be extracted from the bran by means of hot coconut oil. The rice oil may also be produced by expressing mixtures of rice bran and expeller copra cake or by expressing the rice bran alone.

PROTEINS IN RICE BRAN

Proteins are complex substances containing combinations of amino acids. Numerous researches have been carried out to determine the biological value of the proteins contained in various foods of animal or vegetable origin. Experiments in feeding animals, usually albino rats, have shown that some proteins (meat proteins) contain in their make-up certain amino acids which are necessary for the normal maintenance and growth of the animal body. The most important of these amino acids are generally believed to be histidine, lysine, tryptophane, and cystine. The biological value of a protein seems to depend, in general, upon the amount of these particular amino acids which are contained in the protein. Inferior proteins are deficient in these important amino acids necessary for maintenance and growth.

Osborne, Van Slyke, Leavenworth, and Vinograd investigated the hydrolytic products of the protein of the rice kernel. They summarized their results as follows:

The partition of nitrogen among the products of hydrolysis oryzenin, the chief protein of the endosperm of rice, was determined by the Van Slyke method. Compared with the endosperm proteins of wheat or maize, the protein of rice yields relatively much of each of the basic amino acids, arginine, and lysine, and comparatively little ammonia and non-amino nitrogen. In its general amino-acid make-up it more nearly resembles the majority of the proteins of animal tissues than do the proteins of maize or wheat. This may explain the extensive use of rice as an almost exclusive diet in spite of its low protein content.

In the process of polishing rice the embryo goes with the rice bran.

Rice bran contains not only the rice embryo but also some of the rice endosperm (white rice) that is, the interior part of the rice kernel. Jones and Gersdorff investigated the proteins in white (polished) rice and also the proteins in commercial rice bran. They found that the proteins in the white (polished) rice contain the amino acids, histidine, lysine, tryptophane, cystine, arginine, and tyrosine. The proteins in the rice bran were tested for the amino acids, tryptophane, cystine and tyrosine which were found to be present.

As a result of these various investigations it appears that the proteins in rice bran contain the important amino acids (histidine, lysine, tryptophane, and cystine) necessary for maintenance and growth.

Dr. J. Maranon, of the Bureau of Science, investigated the nitrogen distribution in Philippine rice bran by means of Hausmann's method as modified by Osborne. He found that the protein nitrogen is about 8 times the non-protein. Investigation of non-protein nitrogen showed that it contains mostly non-basic nitrogen. The protein nitrogen consists largely

of non-basic nitrogen but also has a considerable amount of basic nitrogen. The data for the protein nitrogen distribution were calculated by the difference between the results of the nitrogen distribution after hydrolysis and the values of the hydrolytic non-protein products. These results agree, in general, with those obtained by Hamada for he found in the protein of the rice embryo more monoamino (non-basic) nitrogen than diamino (basic) nitrogen.

The comparative nutritive value of the proteins contained in rice bran and soy beans has been investigated by Mitchell and Villegas. They determined the actual digestible nitrogen of the protein rations fed. On a 10 per cent. protein ration the results seemed to show that there was no distinct difference between the protein of rice bran and soy beans. The protein of soy beans, unlike, that of other vegetables, is similar to both meat and milk protein and seems to fulfil all physiologic requirements. It would appear that the proteins in rice bran have a high biological value and, like soy bean protein, compare favourably with meat proteins.

RICE BRAN LACKS GLUTEN

Concerning gluten Thorpe states:

Wheaten flour differs from that of all other cereals in that after it has been made into a dough with a little water, it is possible to wash out the starch, leaving a sticky adhesive brown or greyish-brown residue which consists mainly of protein. This is crude gluten: on drying it in a water-oven, a hard, brittle horny mass, not unlike glue, results, which has lost its power of becoming plastic when wetted, and strongly adheres to the substance on which it rests. At a higher temperature, the wet gluten expands greatly until the expansive force ruptures its vesicles.

The flour of other cereals when washed in a similar way entirely disintegrates, leaving no protein residue. The physical properties of wheaten dough depend almost entirely on the gluten, which acts as a mechanical agency for binding the particles of starch and for entangling the carbon dioxide gas produced by the fermentation: in the oven, this gas expands, causing the dough to rise and the gluten to remain distended until the heat fixes it.

Tadokoro studied the chemical properties of glutinous and non-glutinous rice and found they were quite different in various respects.

Rice does not contain gluten. The so-called glutinous rices contain a kind of sticky substance instead of true gluten. When used alone rice bran, lacking gluten, does not make bread which will rise. However, when rice bran is mixed with wheat flour the combination makes a bread which rises nicely and has a good texture.

UNBALANCED MINERAL CONSTITUENTS

Kintner and Holt studied equine osteomalacia (bone weakening) in the Philippines and found that the prevention of this disease depends on the feeding of a ration properly balanced in the important mineral constituents calcium oxide and phosphorus pentoxide. The ration should be so balanced that the calcium oxide-phosphorus pentoxide intake ratio is between 1:1 and 1:1·8. Where there is deficiency in one of these mineral factors this balance may be attained by adding to the ration the required amount of the proper constituent.

Rice bran has a rather high ash content, containing about 10 per cent. Analysis of the ash for calcium and phosphorus has been made by Mr. M. Tirona, formerly of the Bureau of Science. The following results were obtained:

		per cent.
Phosphorus pentoxide (P_2O_5)	...	5·09
Calcium oxide (CaO)	...	0 06

As shown by these data the ratio between the calcium oxide and the phosphorus pentoxide is not well balanced as the percentage of phosphorus pentoxide is quite high in comparison with the percentage of lime, which is very low. The composition of the bran, in this respect, resembles that of polished rice which also contains a relatively high content of phosphorus as compared to lime. In feeding stock this unbalanced ratio could be corrected, in accordance with the suggestions of Kintner and Holt, by adding the proper amount of calcareous constituents to a rice-bran ration or to the drinking water.

According to Sherman 0·45 gram of calcium (0·63 gram CaO) and 0·88 gram phosphorus (2·02 grams P_2O_5) fill the actual daily requirement for adult humans but this represents the minimum of actual need rather than the normal allowance. He considers that the normal allowance for phosphorus should be 50 per cent. above the average minimum while for calcium it should be even greater. He estimates the optimum allowance to be 0·70 gram calcium (1·0 gram CaO) and 1·32 grams phosphorus (3·0 grams P_2O_5). The optimum calcium oxidephosphorus pentoxide ratio is 1·0:3·0 according to these data.

Concerning the use of rice bran as an ingredient of human food this unbalanced calcium-phosphorus ratio is not a serious matter for people who live on a mixed diet. For this ratio could be balanced to a considerable extent by including suitable vegetables in the diet; that is, vegetables which have a high ash content and a relatively large amount of calcareous matter in the ash.

Maranon has recently investigated the mineral constituents of a considerable number of edible Philippine plants.

As shown by the data these vegetables contain considerably more calcareous matter than the phosphoric ingredient. This unbalanced mineral ratio is just the opposite of that in rice bran. The addition of these vegetables to a ration containing rice bran would tend to balance the calcium-phosphorus ratio in the bran.

NUTRITIVE VALUE OF RICE BRAN

Rice bran as a cattle food.—Rice bran should have a comparatively high food value since it contains vitamins, proteins, and fats. These are the most nutritious constituents of the rice grain.

In Louisiana, Texas, and elsewhere in the southern United States rice bran (polishings) has been used in feeding experiments with cattle. The results showed that fresh rice bran, which has a sweet odor, is somewhat better than corn or corn meal. However, if the bran becomes rancid, due to decomposition of the fat contained in it, the cattle do not like

it. Cattle also do not care for rice bran that has been mixed with any considerable quantity of rice hulls. It is generally believed that bran which contains rice hulls is not suitable for use as an edible product.

Lush and Hale fed cows with a mixture consisting of fresh rice bran (90 per cent.) and cottonseed meal (10 per cent.) and found that the ration had no effect upon the flavour of milk given by the cows. They concluded that fresh, non-rancid rice bran is a desirable and economical dairy food.

In the Philippines rice bran has served as cattle food for a number of years. When bran that is not fresh is used for feeding horses an old local custom is to mix the bran with molasses to neutralize the stale taste.

Rice bran has a higher food value than ordinary hydraulic copra cake, which contains about 5 per cent. of coconut oil.

Copra cake is used considerably as cattle food and some buyers prefer a cake which has a somewhat higher fat content than is ordinarily contained in hydraulic copra cake. A mixture of hydraulic copra cake and rice bran in equal proportions gives a combination that has a higher food value than the copra cake alone, for it contains not only sufficient proteins and carbohydrates but more fat. Furthermore, the combination has the fat-soluble vitamins A and E, which are not contained in copra cake. For a cattle food this is a decided advantage since it tends to enrich the milk of the cattle in fat-soluble vitamins.

Rice bran has a much higher food value (calories) than either the wheat bran or the flours. This is due to the fact that the rice bran has a much higher fat content than the wheat bran or flours although the protein and carbohydrate contents are lower.

Recently the Bureau of Science has taken steps to popularise the use of rice bran as a human food. At the industrial exhibition held recently in Manila the Bureau gave an interesting display of bread, cakes, and other bakery products made from rice bran. Miss Orosa has published a popular bulletin on rice bran as a health food and how to cook it. This bulletin gives recipes for making rice-bran biscuits, fritters, croquettes, pudding cookies, and many other tasty foods.

Some people do not fancy the natural flavor of rice bran. For such people the flavor may be toned down considerably by diluting the bran with wheat flour. A mixture of wheat flour (3 parts) and rice bran (1 part) makes a good combination for bakery products such as bread and cakes. This combination has a food value higher than that of wheat flour.

Rice bran, when used alone, lacks gluten and does not make bread which will rise. The addition of wheat flour serves not only to dilute the bran but also to supply the gluten necessary for making bread.

The bran flavor may be still further neutralized or entirely disguised by using other characteristic flavors, such as ginger, cinnamon or chocolate. Bran cookies made with these flavors are very tasty and since they contain vitamins they are quite nutritious.

Rice bran as a preventative of beriberi.—In the Philippines beriberi is a very common and fatal disease among the poorer classes who live on a diet that consists principally of polished rice and is deficient in vitamin B_1. The standard extract of rice bran (tikitiki extract), made in the Bureau of Science, is widely used and has given excellent results as a preventative or cure for beriberi.

According to Van Veen, Jansen and Donath estimate that the amount of antineuritic vitamin B_1 contained in 30 grams of rice bran is probably more or less the quantity required for an adult per diem. This is just about equivalent to 11 level (not heaping) teaspoonfuls of bran or approximately 2 cubic centimeters of standard rice-bran extract (14·5 grams of high-grade bran make 1 cubic centimeter of extract).

In the Philippines more than 111,000 tons of fine rice bran are produced annually as a rice-mill by-product. Estimating the population of the Islands at 13,000,000, this is sufficient to supply each person daily with about 23·3 grams of fine rice bran. People who live on a mixed diet do not require the bran for its medicinal value so the annual production of rice bran is probably about sufficient for all the people who really need it and for others who would benefit by using it.

In a very few localities in the Philippines the people have for years been used to eating a kind of cake made from a mixture containing some fresh rice bran. If this use of rice bran as a human food could be popularized and people all over the Islands become accustomed to eating bakery products or other foods containing rice bran, then deaths from beriberi would be a rarity. It would not be necessary for the poorer classes to take extract of rice bran as a preventative or cure for beriberi.

DETERIORATION OF RICE BRAN

Insect infestation.—When rice bran, fresh from the polisher, is allowed to stand for a day or so the bran become infested with insects. Unhulled rice grains frequently carry insect eggs that have been deposited upon the grain in the field before the grain is brought to the mill. Again, insects breed freely in rice bran which accumulates about the mill. There is a Philippine Ordinance which provides that rice mills shall be cleaned of all waste once a day but this regulation is not strictly enforced. We visited mills which were really very clean but there were others which presented quite a different appearance. In the Philippines, as in the United States and other countries, insect infestation is one of the important problems connected with the milling industry.

W. Schultze, formerly entomologist of the Bureau of Science, has identified the following insects which infest unpolished rice:

Rice weevil, *Sitophilus oryzae* Linn.

Rice moth, *Corcyra cephalonica* Staint.

Rust-red flour beetle, *Tribolium ferrugineum* Fabr.

Granary weevil, *Sitophilus granarius* Linn.

Vedder and Feliciano found that when these insects infest unpolished rice they prefer to eat away the most nutritious part of the grain. This is the external layer or that portion removed during the polishing process. These insects thus convert an unpolished rice into a polished rice. Samples of unpolished rice which were infested with insects for one hundred days were analyzed before and after the period of infestation. The results showed a very decided decrease in the percentage of fat and phosphorus pentoxide. Unpolished rice, which before the infestation was beriberi-preventing, thus lost this medicinal property.

Heat for controlling insects in flour mills and grain elevators has been used considerably in the United States. Dean, who investigated this problem, found that a temperature of only 118° to 125°F., (48° to 51·5°C.), maintained for several hours to enable the heat to penetrate all infested parts, which kill all insects and insect eggs. The heat, obtained from steam pipes, does not injure the grain and is more efficient than fumigation.

We found, as stated later, that insect infestation in rice bran may also be prevented by heat.

Decomposition of rice oil.—The deterioration of rice bran is not only caused by the ravages of insects but also by the decomposition of the fatty oil contained in the bran. Pure vegetable fats, or fatty oils, usually consist almost entirely of a mixture of glycerides of fatty acids. Rice oil, for instance, consists principally of the glycerides of oleic, linolic, and palmitic acids. Under certain conditions, such as the action of moisture and enzymes, these glycerides are gradually decomposed (hydrolyzed) and converted into glycerol and a mixture of free fatty acids. The free acids may then undergo oxidation and the fats acquire an unpleasant odor and taste, and become rancid. However, a high acid number is no indication of a rancid fat for rancid fats may contain either small or very large amounts of free fatty acids. According to Lewkowitsch the initial phase of rancidity (hydrolysis) is accelerated by the action of enzymes. Fat-hydrolyzing enzymes occur in most, if not all, oleaginous seeds. The freshest vegetable oils and fats always contain at least minute quantities of free fatty acids. The formation of free fatty acids in vegetable oils is due to the action of moisture in the presence of enzymes (soluble ferments) which act as catalysts and accelerate the hydrolysis of the fats. Thus olein $(C_{17}H_{33}COO)_3C_3H_5$, the fat which is the glyceride of oleic acid, when hydrolyzed yields glycerol, $C_3H_5(OH)_3$, and oleic acid, $C_{17}H_{33}COOH$.

$$(C_{17}H_{33}COO)_3C_3H_5 + 3HOH \rightarrow C_3H_5(OH)_3 + 3C_{17}H_{33}COOH.$$

For convenience it is usually customary to calculate the amount of the free fatty acids in vegetable oils simply as oleic acid.

At ordinary temperatures moisture alone is not effective in decomposing vegetable free oils (glycerides). According to Lewkowitsch:

At temperatures up to about 150°C., water does not attack glycerides but if the temperature be raised to 200°C., or more, the triglycerides are finally decomposed (hydrolyzed) into their proximate components, glycerol and fatty acids. The hydrolysis thus produced at high temperatures is greatly accelerated if the action of the water is assisted by suitable chemical agents. If such agents are present, it is possible to reduce the

temperature . . . the change may be brought about by water even at the ordinary temperature if naturally occurring ferments, such as lipase or steapsin, are intimately intermixed with the oils and fats.

Rice bran as it comes from the polisher has a fresh and somewhat sweet odor. If the bran is obtained from rice milled soon after the harvest the amount of free fatty acids in the fatty oil contained in the bran is usually very low. We found samples of bran that gave only 1·2 per cent. of free fatty acids in the rice oil. Perhaps if the mill had been thoroughly cleaned before milling the grain the percentage of free fatty acids would have been even smaller. Samples of bran from grain which had been stored for some months gave a much higher percentage of free fatty acids in the rice oil ranging from about 2 to 6·5 per cent. From our results it would seem that, due to the action of moisture in the presence of enzymes, the fatty oil in the unhulled rice grain gradually decomposes to some extent when the grain is stored. Perhaps this is the reason that polished rice from freshly harvested grain has a better flavor than rice milled from grain that has been stored a long time. During the polishing process not all of the outer aleurone layer containing fats is removed from the rice kernel, for the polished rice still contains over 1 per cent. of fat. If the fats which remain with the polished rice are acid they may have a flavor which is not so agreeable as that of the pure glyceride (fats). Compared with other foods rice has relatively little flavor and so the presence of even a small amount of acid fat may, perhaps, affect very appreciably the flavor of polished rice.

The fatty oil in rice bran, fresh from the polisher, may contain only a very small percentage of free fatty acids but when the bran is allowed to stand there is a very rapid increase in the amount of free fatty acids contained in the fatty oil with a corresponding decrease in the amount of pure fat.

According to Browne this rapid decomposition of rice oil is due to a fat-splitting enzyme (lipase). Excessive acidity has been observed in a few other vegetable oils, such as palm and olive, and has been found to be due to enzyme action.

Concerning the production of palm oil in Africa Lewkowitsch states:

In consequence of the very crude mode of producing palm oil, causing it to remain for a considerable time in contact with fermentable vegetable tissue, hydrolysis rapidly sets in, so that the oil on reaching the coast contains already a notable amount of free fatty acids. Palm oil when shipped from the coast has at least 10-12 per cent. of free fatty acids. The process of hydrolysis, once begun, continues in the barrels during the voyage, and in consequence thereof commercial palm oils, on arriving at their destination, contain frequently from 20 to 50 per cent., and even more, of free fatty acids. In such palm oils free glycerol is found. In old samples the hydrolysis may even reach completion, so that such palm oil practically consists of free fatty acids. The progress of hydrolysis can be observed even in oils kept in glass bottles. Thus a sample of Drewin oil, which had originally the acid value 41·8, showed after six (summer) months the acid value 70·1.

In the case of rice oil we have a condition somewhat similar to that of commercial palm oil. Rice bran as it comes from the polisher contains fatty oil in contact with fermentable vegetable tissue. The rice oil in the bran contains free fatty acids showing that hydrolysis of the oil has already started before milling the grain. The longer the oil is allowed to remain in contact with the vegetable tissue the greater will be the production of free fatty acids unless something is done to stop the action of the enzyme and the decomposition of the oil.

Cattle frequently show a marked distaste for rice bran as a food. It has been found, in such cases, that the bran has a rancid taste. The oil in rancid bran usually has a high acid number indicating that the fats (glycerides) have decomposed and, to a considerable extent, have been converted into free fatty acids.

The greater the amount of free fatty acids contained in the oil of fresh bran the greater the amount of hydrolysis.

We determined the daily hydrolysis of the fatty oil when rice bran is stored for twenty-one days. In the first sample of bran tested the acid number of the oil in the fresh bran was 4·88 and in the second sample it was 8·89. These samples of bran were taken fresh from the polisher, placed in bags of cheesecloth, and stored in a wire screen box. They were thus exposed to atmospheric moisture but protected from insects.

PRESERVATION OF RICE BRAN

Preliminary heating experiments.—According to Browne the activity of the fat-splitting enzyme contained in rice bran can be retarded very considerably by heating the bran to a temperature of 90°C. To prevent the formation of free fatty acids in rice oil and the resulting rancidity Browne suggested heating the bran, immediately after milling, to a dry heat sufficient to destroy the enzyme, such as is done in the kiln-drying of certain seeds.

Since a double wrapping of moisture-proof cellophane preserved the bran better than any other wrapper we used it would seem that preservation of the bran, after heating, depends principally on excluding moisture and insects.

Enzymes in rice bran.—The fact that we had to heat rice bran at a temperature of 100°C., for six hours to check the action of the fat-splitting enzymes would seem to indicate that the enzymes in rice bran, like certain enzymes from other sources, have a considerable tolerance for heat.

Heating the bran removes moisture and stops the destructive action of enzymes, as most of them are destroyed. This prevents decomposition and subsequent rancidity of the fatty oil contained in the bran. The heating does not affect the vitamins but destroys any mold spores, insects, or insect eggs which may be in the bran. When stored in moisture-proof containers, the heated bran does not become rancid, moldy, or infested with insects.

Bacteria in rice bran.—If the fatty oil in rice bran has the general properties of other vegetable fatty oils then the decomposition (hydrolysis) of rice oil in rice bran is due to moisture in the presence of fat-splitting enzymes contained in the tissues of the bran. The question might be raised that, possibly, bacteria as well as enzymes may, perhaps, be active in

decomposing the fatty oil in rice bran. In order to settle this question we heated rice bran at a temperature of 120°C., for six hours. During the heating the bran was stirred continually. The heating destroyed the bacteria and also any mold spores or insect eggs that may have been in the bran. A portion of the hot bran was quickly placed in a sterilized bottle which was stoppered with sterilized cotton. Another portion of the heated bran was placed in an open vessel and thus exposed to bacteria in the air. This bran was stirred occasionally and allowed to stand in the air for four hours. It was then placed in a sterilized bottle which was stoppered with sterilized cotton. These two samples were covered with paper to keep out dust and allowed to stand in the air, under identical conditions, and absorb moisture through the cotton stoppers for 31 days.

The first sample quite likely contained only a very few bacteria while the second, which was allowed to stand in the air, certainly had considerably more than the first. For comparison we simply designated the first sample as "without bacteria" and the second as "with bacteria". The results of these experiments are recorded in table below.

Effect of bacteria on the decomposition of rice oil in rice bran.

(The bran was heated at 120°C., for six hours and stored for thirty-one days, exposed to moisture, in sterilized bottles.)

	Moisture		Acid number of oil in bran	
Rice bran	Before storing	After storing	Before storing	After storing
Without bacteria [a]	...	4·50	4·60	6·18
With bacteria [b]	...	4·73	[c] 4·60	6·45

a The bran, heated for six hours at 120°C., was placed immediately in a sterilized bottle which was stoppered with sterilized cotton.

b The bran, heated as above, was placed in an open vessel and exposed to the air, with occasional stirring, for four hours. The bran was then placed in a sterilized bottle which was stoppered with sterilized cotton.

c The acid number was determined after heating the bran and not after exposing it to the air for four hours.

If bacteria are active in hydrolyzing rice oil then, after storage, the rice oil in the bran with bacteria should have a much higher acid number than the rice oil in the bran without bacteria. As shown by the data both samples gave about the same results so evidently the decomposition of rice oil in rice bran is not due to bacteria.

The acid number of the rice oil in both samples of bran increase slightly during storage. This would seem to indicate that the enzymes in rice bran are not totally destroyed even after the bran is heated at a temperature of 120°C., for six hours. Apparently a very few still remain somewhat active.

The rice oil in the bran with bacteria gave a slightly greater increase in acidity, during storage, than the oil in the bran without bacteria. This was probably due to the fact that the bran with bacteria was stirred in

the air for four hours before bottling and absorbed more moisture than the bran without bacteria. Both samples of bran were moisture free immediately after heating.

Sieving rice bran before heating.—Commercial rice bran usually contains some fragments of rice kernels or polished rice. It may also have some broken rice hulls or other foreign matter if the bran has not been milled properly. If the bran is to be used for making bakery products or other foods, it should be sieved as it is not desirable to have hard particles in the bran and moreover rice hulls are considered to be injurious for human consumption. In sieving the bran the hard particles are retained by the sieve. The question naturally arises as to how much of the nutritious constituents are removed from the bran by sieving it. We obtained two samples of fresh rice bran (200 grams each) and, by analysis, found the oil content of one to be 21·88 per cent. (calculated on a moisture-free basis) and the other to be 23·51 per cent. This showed that these samples of bran were not purposely adulterated with rice hulls. These samples were sieved through a large, 30-mesh, inclined sieve. Dr. A. J. Hermano tested the fine bran which passed through the sieve and also the coarse material retained by the sieve for the fat-soluble vitamin A and the water-soluble vitamin B_1. Both the fine bran and the coarse material gave positive tests for these vitamins.

The coarse material consists largely of fragments broken off from the surface of the rice kernel. These fragments contain a considerable portion of the aleurone layer of the rice kernel and therefore they contain rice oil, fat-soluble vitamins and also the water-soluble vitamin B^1.

Rice oil and vitamins (A and B_1) in sieved bran

Sample	Bran retained by 30-mesh sieve			Bran passing through 30-mesh sieve		
	Amount	Vitamins (A and B_1)	Oil content of bran	Amount	Vitamins (A and B_1)	Oil content of bran
	per cent.		per cent.	per cent.		per cent.
1	13·00	Positive	24·81	87·00	Positive	21·59
2	15·50	do	24·25	8·50	do	23·19
Average	14·25	...	24·53	85·75	...	22·39

As shown by the data an average of 14·25 per cent. of coarse material was removed from the bran by sieving it. This is about 1 per cent. less than the average of the results recorded. Since this coarse material contained 24·53 per cent. fatty oil then the amount of fatty oil removed from the bran by sieving was about 3·5 per cent. ($14·25 \times 0·2453 = 3·49$). The coarse material removed by sieving is very suitable for feeding chickens or for other purposes.

In sieving rice bran through a large, 30-mesh, inclined screen the bran does not sieve by mechanically shaking the screen because there are no oval solid particles, like rice grains, to roll down the screen. However, if the bran is spread over the screen in a thin layer and the screen is tapped frequently with a rod, so that the screen vibrates perpendicularly,

then the fine bran will pass quickly through the screen while the coarse material is retained. The coarse material is then removed and a new portion of bran spread over the screen.

Rice-bran cooker.—The Bureau of Science has recently installed a rice-bran cooker. This cooker is a drumshaped apparatus which has an internal diameter of 100 centimeters and an internal height of 40 centimeters. The side and bottom are surrounded by a jacket through which steam may be admitted when the cooker is in operation. In the interior of the cooker and very near the bottom there is a stirrer with four iron paddles that serve to stir the bran when it is heated. Layers of asbestos wrapped around the outside of the cooker prevent loss of heat. This cooker heats the bran satisfactorily, in fact, the bran may be heated easily to temperature of 125°C.

Our method for preparing rice bran so that it will keep in storage is as follows: Bran fresh from the polisher is sieved through a large, 30-mesh screen by tapping the screen so that it will vibrate perpendicularly. The coarse material which does not pass through the screen, may be discarded and used for feeding chickens. If it does not contain rice hulls or other foreign matter it may be ground finely and returned to the bran. The sieved bran is then placed in the cooker and heated, with continual stirring, for three hours at a temperature of about 105°C. Stirring the bran facilitates the removal of moisture. The bran while still hot is then packed in moisture-proof containers or packages. When prepared in this manner it will keep in a fresh condition for a considerable length of time.

Although the heated bran is slightly darker in color than the fresh, raw bran it has a pleasanter and sweeter odor and flavor than the raw bran.

Heating bran in outlying districts.—In outlying districts it is often not feasible to procure bran which has been properly heated in a cooker and stored in moisture-proof containers. Bran which will keep in storage for a short time may be prepared in a rather crude manner at home. This is done by simply heating fresh bran in a frying pan over a low fire. The bran should be stirred continually and heated about an hour or so until it turns slightly darker than the fresh bran. Care should be taken not to burn the bran. After it is heated the bran should be placed in a can or glass jar and this closed tightly to prevent entrance of moisture. This crude method removes nearly all of the moisture from the bran and by storing it in containers which are fairly airtight the bran will keep in good condition for a week or more.

Rice bran is at present a very cheap substance and contains fats, proteins and vitamins that are the most nutritious constituents of the rice grain. Excellent bakery products and other foods may be made from rice bran. When it is not convenient to procure fresh bran the heated bran, preserved in proper containers, may be used. It is preferable to use the heated bran because it keeps better than raw bran.

IMPORTANCE OF CALCIUM IN DAIRY RATIONS*

COWS require a supply of digestible protein, sugars, starches and fats from the feed sufficient to maintain the body in good health, and to provide the proteins, milk sugar and butterfat in the milk. In addition, they need small but definite amounts of calcium, phosphorus, common salt and other mineral elements to maintain themselves, and to provide the mineral matter in milk. A hundred pounds of milk contains nearly nine-tenths of a pound of mineral matter, or about 0·7 pound of ash. This amount of ash contains about 0·17 pound of calcium oxide (lime) and 0·22 pound of phosphorus pentoxide. Fortunately, cows do not change the amounts of calcium and phosphorus in milk to correspond with the levels in the feed.

In the natural feeds, calcium (lime) occurs mainly in the roughages. Legume hays usually contain from four to five times as much lime as do grasses grown on the same land. On acid, low-lime soils, even the grasses build less lime into the forage than on high lime soils. Grains and milling by-products, especially wheat bran and the oilmeals, contain a good proportion of phosphorus. If rations for dairy cows contain a fair proportion of legumes and grains, there seldom is need to consider the necessity of additional mineral matter. However, if these are not in good proportion, or if the soil upon which they were grown was deficient in these elements, then provision must be made to supply them.

Cows normally store calcium and phosphorus in the skeleton in times of surplus, and draw upon them when in heavy milk production, or when the feeds are deficient in either of these elements. If the feeds contain an inadequate supply of minerals the cows continue to draw upon the supply in the skeleton until the bones become extremely weak, and are easily broken. The milk yield then decreases in proportion to the minerals supplied by the feeds. After this condition is reached, even if the lacking mineral elements are supplied, the milk yield cannot be expected to return to normal until after the next calving.

A study of this condition has been made over a period of years at the Florida Experiment Station. The feeds given to the station dairy herd during the first part of the study included pasture grasses and corn, sorghum or cane silage as the roughages used with a mixture of ground corn, bran, cottonseed meal and other concentrates. The forages are grown on acid sandy soils. Rations containing them were calculated to provide only a part of the calcium needed, although the phosphorus content was adequate. While receiving these low-calcium rations, an unusual proportion of the dairy cows had broken hips and ribs. The leg bones from a

* By R. B. Becker, W. M. Neal and A. L. Shealy, Animal Husbandry Department, Florida Experiment Station, in Press Bulletin 457, June, 1933.

cow with a newly-broken pelvis had an average breaking strength of only 335 pounds. Records were assembled of 12 Jersey cows receiving the low-calcium rations. These cows had 44 complete lactations which averaged 3,980 pounds of milk per lactation.

A change was made in the feed by adding two pounds of finely ground feeding bonemeal per 100 pounds of concentrates. While these same 12 Jersey cows were in good state of mineral storage, their milk records increased to 6,425 pounds per lactation (average of 22 lactations). These records were made by cows of different ages, but even when calculated to a uniform age basis, the 12 cows produced over 50 per cent. more milk on the supplemented rations than they did on the low-calcium rations. Tests made on the bones of eight of the same Jersey cows showed that the mineral matter had been restored to such an extent that the heavy leg bones had average strengths in excess of 3,000 pounds. This mineral matter could have been drawn upon for milk production.

When cows depend on pasture grasses and silages as the sole sources of roughage, it is desirable to supply added calcium in the form of bonemeal, up to 2 per cent. of the concentrates. Bonemeal is a practical and economical form of mineral matter for this purpose.

MEETINGS, CONFERENCES, ETC.

RUBBER RESEARCH SCHEME (CEYLON)

Minutes of the nineteenth meeting of the Board of Management, held at 11 a.m. on Thursday, November 23, 1933, in Room No. 202, New Secretariat, Colombo.

Present.—Dr. W. Youngman (in the chair), Messrs. C. W. Bickmore, C.C.S., (Deputy Financial Secretary), I. L. Cameron, B. F. de Silva, C. E. A. Dias, J.P., H. R. Freeman, M.S.C., L. P. Gapp, F. H. Griffith, Col. T. G. Jayewardene, V.D., M.S.C., Messrs. J. L. Kotalawala, M.S.C., F. A. Obeyesekere, M.S.C.. C. A. Pereira, E. C, Villiers, M.S.C., E. W. Whitelaw and Col. T. Y. Wright.

Mr. T. E. H. O'Brien, Director of Research, was present by invitation, and acted as Secretary.

Apology for absence was received from Mr. B. M. Selwyn.

1. MINUTES OF THE EIGHTEENTH MEETING OF THE BOARD

Draft minutes which had been circulated to members were confirmed and signed by the Chairman.

2. BOARD

The Chairman reported the resumption of membership by Col. T. Y. Wright on his return to Ceylon.

3. DEVELOPMENT OF THE RESEARCH SCHEME

(a) Minutes of meetings of the Estate Committee held on October 23 and November 6, 1933, were considered under the following headings :—

Crown land for experiments.—In connection with the Committee's recommendation to apply for 100 acres of Crown land at Pinnagoda for experimental purposes the Chairman reported that it would be necessary to submit a detailed statement of the use to which the land would be put, before the matter could be considered by the Executive Committee for Agriculture and Lands. It was decided that a statement should be prepared.

Estimate for Dartonfield Estate 1933.—An estimate of expenditure for the period August-December, 1933, amounting to Rs. 5,312 was approved.

Estate Superintendent.—The Committee was authorized to proceed with the appointment of an Estate Superintendent on the terms advertised.

Experimental Factory.—The proposal to erect an experimental factory at Dartonfield was approved and the Committee was authorized to call for plans and estimates from local engineering firms.

(b) *Research on the utilisation of raw rubber.*—The policy of the Research Scheme in relation to research on the utilisation of raw rubber was discussed in connection with a letter from the Hon'ble the Minister for Agriculture and Lands, drawing attention to the inadequacy of the results achieved in this direction up to the present. The Director of Research was instructed to prepare a memorandum giving particulars of progress in this branch of work to date and submitting proposals for future work.

4. ACCOUNTS

(a) *Estimates of Income and Expenditure for 1934.*—Draft estimates of income and expenditure for 1934 were considered. After full discussion, during which it was decided to make provision for the appointment of a Secretary and to consider staff salary scales at a future meeting, the following estimates were adopted :—

Income	... ...	...	Rs. 147,830
Expenditure	Recurrent	Rs. 114,962	
,,	Non-recurrent	,, 78,300	,, 193,262

(b) Statements of receipts and payments of the Board and of the London Advisory Committee for the quarter ended September 30, 1933, were adopted.

(c) Experiment Station accounts for September and October, 1933, and Dartonfield Estate accounts for August, September and October, 1933, were tabled.

5. APPOINTMENT OF AN ASSISTANT CHEMIST

The Chairman reported that 79 applications for the appointment had been received and had been considered by the Selection Committee. The Committee recommended 3 candidates in order of preference. The choice was approved by the Board and the Chairman was authorized to offer the appointment to the first candidate by cable, subject to a satisfactory medical certificate being submitted. It was decided that the officer should be asked to spend 2 weeks at the laboratories of the London Advisory Committee before proceeding to Ceylon.

6. TECHNICAL REPORTS

The following reports were tabled, prior to publication :—

"Method of Preparing Raw Rubber in Crumb and Powder Form". —G. Martin.

"The Preparation of Soft Rubber with Sodium Nitrite".—G. Martin

"Notes on Low Temperature Vulcanization.—T. E. H. O'Brien.

DEPARTMENTAL NOTES

ANIMAL HUSBANDRY IN CEYLON*

WE have been instructed by the Hon. the Minister for Agriculture to submit a scheme embodying proposals for the extension of animal husbandry in Ceylon.

We have had numerous meetings, considered various proposals and efforts, reviewed present activities of the Veterinary and Agricultural Departments, and visited and studied the situation on the spot at different centres. Mr. Crawford was especially active during the absence of the Director of Agriculture on short leave in preparing a "Survey of Livestock Breeding in Ceylon at the Present Time, with suggestions for Developments" which is published as an Appendix to this report. The present situation is well set out in this survey and it need not again be gone into here. The object herein will be to set forth our views as to methods and suggestions for improving the existing state of affairs.

After carefully reviewing the whole situation as indicated above we have come to the considered decision that *the only chance of effecting any real and lasting improvement in the present neglected state of animal husbandry would be to concentrate effort on improvement in a limited area.* More especially do these remarks apply to improvement of the Island's neat stock.

An intensive effort should be made in a limited area to introduce castration of inferior village bulls, to supply suitable stud bulls, to attack the admittedly difficult problem of pasture improvement under the adverse conditions of common pasturage, and to inculcate the growing and storage of fodder.

The choice of an area where such a campaign should be initiated has received our deliberation. We consider that for the measures we recommend to be successful the area chosen as the first one should receive as large a measure of approval as possible from the people themselves and their representatives on the Ministry of Agriculture and in the State Council. We therefore consider everything would be gained by leaving the choice to them. All we would here say is that the smaller the area in the first place the more likely the success. It should not by any means be so large as any Provincial territory. Success is more likely to be achieved by tackling one area and then when progress has been made there another contiguous region could be attacked. An effort such as we envisage involves the concentration of Veterinary and Agricultural staffs, propaganda to secure so far as possible the good-will and interest of the people and to educate them on the subject, and at the same time necessary support and co-operation from the Headmen.

* Sessional Paper XXVII—December, 1933.

Castration and thus control of promiscuous breeding from worthless types of scrub bull is essential for cattle improvement.

An attempt to carry out castration over the whole country or as a piecemeal objective would never produce anything in the nature of an advance, it must be an intensive method of control worked at first in defined areas and continued for some years.

The only way, it occurs to us that this could be done would be to castrate all worthless bulls at the time of branding. This could only be worked in co-operation with the headmen and Village Committees. A measure of compulsion would have to be introduced. Village Committee rules on the subject and their enforcement must be introduced. Selection of the area would be a matter of considerable importance in securing the success of such a project.

Stud bulls.—The system of scattering stud bulls about the country is not likely to produce any results of value. A limited area must be decided upon. The type of stud bull would have to be chosen in accordance with the need and type of cattle in this area.

Pasture improvement is a very big problem, much more so than is usually realized by those so commonly advocating it.

The opportunity offered by coconut estates in Ceylon for cattle improvement is a very great one. They are the property of the landed gentry class who should find congenial employ in cattle breeding, they are practically the only enclosed fenced paddocks where the animals are under control and their pasturage is or could be very well suited to the purpose. The drawback is that the breeder is not ensured of a ready market for his stock after he has bred it. The 500 bulls imported per annum for the Jaffna market could easily be reared on coconut estates. The possibilities of milk, or ghee manufacture, although not fully explored, are probably not sufficiently attractive at present in the absence of collecting and distributing centres in towns.

The improvement of common village pasturage is a notoriously difficult problem. Indeed so far as we have been able to explore the situation in other countries it may be said that cattle improvement has generally best, if not only, been effected by the disappearance of common pastures and their substitution by individual holdings. Common grazing grounds are generally saturated with common disease and what is co-operatively every man's duty to limit areas or seasons of grazing in order to give rest and effect improvement is generally no man's duty. Possibly the greatest hopes for improving village grazing areas would be by a system of rotational clearing of unwanted growth, resting and grazing of certain portions. This can only be achieved by associated agreement and action. Whether in the future Village Committees can introduce and maintain such a system must be seen.

Furthermore, we have been struck by the similarity of the elements in our pastures in most parts (Tamankaduwa is a noticeable exception) to those in the Southern Coastal Belt in New South Wales where grasses and plants have been shown to be greatly deficient in lime and phosphorus, resulting in small boned animals and progressive deterioration due to deficiency diseases. Improvement of such conditions by clearing away shrubs and

bushes which generally intersperse if not largely cover our pasture areas, the amelioration of the intervening soil by fertilizers, and the introduction of other grasses which would grow in the altered soil such as have been utilized in Australia can hardly be hoped for in common pasturage unless the villager can be educated to a much higher order of things than at present. An attempt to introduce such education might be undertaken on an exemplary scale on at least some pasture grounds in a limited area selected for the intensive improvement campaign previously discussed. Co-operation from all, especially Revenue Officers, and funds, would be essential.

An investigation into the suitability for pasturage of indigenous and imported grasses has been started at Peradeniya. This work will have to be continued for some time before it can be applied. It is work of fundamental importance.

Fodder growing must be encouraged in the same area as the castration and stud bull experiment. It will be a big effort and from the nature of things quick results cannot be expected. A demonstration station may have to be opened which could also be the headquarters for housing the stud bulls.

The introduction of the use of fodder would mean also the introduction of stall feeding which would probably be one of the biggest agricultural advances in peasant agriculture in the Island, for it would lead on eventually to a system of mixed husbandry with conservation of cattle dung and with animals and plants both playing a full part in the scheme of agricultural economy. The preparation of silage and the feeding of concentrates would be the final stage.

With regard to the practice of ensilage, although we consider the immediate problem to be an increased quantity of food and even if the increased food is not ideal more food of some sort would be an advance, yet we doubt if a stage has been reached when general use of this process can be expected in the villages. The supplying of mineral supplements to the ration was considered by the Committee appointed in 1929 to report on the Improvement of Cattle Breeding in Ceylon to be a necessity. This is more so if silage is to be fed as such food is of high acidity. The preparation of silage demands much labour. To fill even a small silo requires a large number of people working at high pressure so that work may be done in a short time which is a factor of successful silage making. Further, in the wet zone there is no need for silos, growth of grass is continuous practically throughout the year. In some parts of the dry zone silos could possibly be of value but it is exactly in these areas that labour shortage is most acute.

Propaganda to disseminate knowledge of the value of milk in the dietary of the people.—In addition to the preceding environmental factors that must be tackled there are certain aspects of the problem that would give to those concerned greater encouragement to improve the neat stock. Firstly we consider considerable propaganda should be carried out to demonstrate the great value of milk and milk preparations in the diet of the people. Even in our villages where there might be abundance the comparatively little esteem in which fresh milk is held is amazing.

The regulations in force in our municipalties to ensure that the vending of adulterated milk is prevented require in many cases stricter enforcement. The sale of watered milk is a very common and equally profitable occupation. It is known that contracts are put out by public institutions including hospitals at rates that make the supply of pure fresh milk unlikely.

It is considered that extensive propaganda by the Medical and Educational Departments to show the value of milk, ghee, and other milk products in the dietary of the people should be undertaken. An extended use of milk is much to be desired both from the point of view of the health of the people and the disposal of a useful village product. This would in the long run be a great stimulus to cattle improvement. The establishment of co-operative diaries under Municipal control should be introduced wherever possible.

The supply of fresh milk in towns is in most countries in the hands of private commercial enterprises which are able as a rule to make the undertaking a financial success. We see no reason why this should not eventually be possible in Ceylon provided (*a*) an awakening to the realization of the value of pure milk be stimulated in the people, and (*b*) legislation be enacted and enforced to prevent the purveyor of adulterated milk from depriving the honest vendor of reasonable trade and profits.

Ghee making.—With the object of providing a remunerative outlet for milk in areas where it is available the establishment of a ghee depôt might be tried. It is only if cattle breeding can by some means be made profitable that an improvement of the cattle can be expected.

As a result of a recent tour made by Mr. Crawford, he suggests as a suitable place for initial tests of the possibilities of a ghee depôt the village of Tambala, about 9 miles from Polonnaruwa.

Marketing facilities in respect of cattle want considerable encouragement. The establishment of periodical markets at short intervals at central places, or even annual cattle fairs in cattle breeding districts, should be encouraged.

Encouragement from Government for cattle improvement might well be given by a progressive annual restriction up to totality in a few years of the draught oxen now coming in through Kayts. These draught oxen are now required mostly in the North and some 500 head per annum would satisfy existing demand. If any progress be made in the permanent cultivation of dry land in the Island the demand for plough oxen should then proportionately increase. The absence of this type of agriculture where animal and arable husbandry both play their part in agricultural economy is one of the causes of the poor state of cattle in the country.

Apart from neat stock improvement there is also need for attention to be given to the encouragement of improvement and breeding of buffaloes. There is a short supply already of these animals in some provinces and if any conditions be instituted that would make an increase of paddy cultivation an economic possibility the provision of more buffaloes would be a primary necessity.

II. REVIEW OF EXISTING GOVERNMENT EFFORTS FOR CATTLE IMPROVEMENT

(A) Subsidary

(1) Identification and separation of various species of indigenous grasses and leguminous plants suitable for pasture and their testing under grazing conditions have been actively put in hand at Peradeniya.

(2) Similar work is in progress in connection with exotic species.

(3) Work on fodder grasses has been done at Peradeniya for a long time and there are many useful introduced varieties now grown on experiment stations and by enlightened cattle keepers in various parts of the Island. This work still continues and new fodders are continually under test. The Veterinary Department has in the past made a speciality of Napier grass and done much through its officers to introduce it to Ceylon. Almost all our fodder grasses are at present grown from cuttings. A good grass that can be grown from seed is wanted. Establishing a fodder area by planting cuttings is an expensive and laborious procedure. If supplies of seed of a suitable grass could be available considerably greater progress might be possible.

(4) Ensilage and its feeding under proper control with an additional supply of lime and phosphates are practised at Peradeniya. Whilst this is a valuable adjunct to enlightened cattle keepers where an all year supply of fresh fodder is not available it is not seen that its general application in the country side can at this stage be expected.

(5) Technical instruction in animal breeding, the care of a milking herd, the production and handling of clean milk and the manufacture of dairy products are now subjects of practical demonstration at the Farm School, Peradeniya, on a scale such as they have never been before. As the dairy herd extends these facilities should be extended and everything be done to expand and keep up to date the dairy instruction at Peradeniya. Eventually if sufficient interest developed short extension courses for those engaged in the dairy industry might be instituted.

B. EXISTING GOVERNMENT HERDS AND DAIRIES

1. Colombo Dairy

The Government Dairy, Colombo, was started in 1893 and was attached to the old School of Agriculture under Mr. C. Drieberg. The object of the dairy was to supply milk to the various hospitals in Colombo and to serve as a demonstration of methods of dairying suitable for use in Colombo.

It started with 47 head of cattle, of which 21 were Sind cows. Importation of batches of Sind cows from Karachi were made at frequent intervals to maintain the stock.

The dairy was transferred to the charge of the Government Veterinary Department in 1901.

From its beginning until 1920 it was stationed in Colombo close to where the Royal College now stands and the cows grazed on the racecourse. In 1920 it was removed to its present site at Narahenpita.

It has served its purpose of maintaining a supply of pure milk to the Colombo hospitals and has been able to do this at a profit. The stock for many years consisted largely of Sind cows.

In 1925 Ayrshire bulls were imported and crossed with the Sind cows. The first cross cows have proved very suitable for Colombo conditions. Second and third crosses of Ayrshire blood have not been so satisfactory.

The present policy is to use both Ayrshire and Sind bulls with the object of maintaining a balance between the two. The policy gives a hardy profitable cow well suited for commercial dairying under Colombo conditions.

The average stock consists of 100 cows in milk, 50 dry cows and the usual calves and young stock, in all numbering about 300.

2. *Government Farm, Ambepussa*

This farm was started in 1913 on a block of jungle land on the banks of the Maha-oya. The object was to provide a place where young heifers from the Government Dairy could be reared until ready to calve and join the dairy herd.

The cattle are reared largely on pasturage and fodder grasses, very little concentrates being used. The land is very favourable for growing fodder grasses. A pasture of local grasses has been formed by clearing jungle and weeding out unsuitable plants. This has been a slow and rather expensive process but a fairly satisfactory pasture has been produced.

Much damage was done by ticks. This has been greatly ameliorated by the building of a dipping tank in 1926. All cattle are now regularly dipped once a week.

Goats.—A small herd of local goats was introduced in 1931 with the object of studying the breeding, rearing, and diseases of these animals in the low-country. The development of the herd was checked by a severe outbreak of Pleuro-Pneumonia in 1932. These goats subsist entirely by grazing. No concentrates have ever been fed.

Results were not very satisfactory. A marked improvement in the condition of the flock has been observed in the past few months following the supply of a cheap mineral mixture. This is composed of equal parts of salt, slaked lime and bone meal. It is kept before the goats at all times in an open box and is eagerly taken by them. Following the use of this the prospects of successful development of the flock are much better than before.

Poultry.—These were introduced to the farm late in 1932 by the purchase of 4 pens of utility R. I. R. from Great Britain. So far results have been very satisfactory and the stock now numbers over 300 head.

Eggs are sold for hatching and cockerels are sold and also distributed free for the improvement of village poultry.

3. *The Farm School, Peradeniya*

The Farm School herd of pedigree red Sind cattle is now one of the features of Peradeniya. Although at present small it is one of the finest herds of this Zebu breed in the world and has been visited and greatly admired by prominent European and Australian herdsmen. It was orginated in 1923-24 when 1 bull and 8 cows were imported from India. A further 4 cows with calves and 1 bull were imported from Karachi in 1926. The

herd now numbers 76 and contains 24 cows in milk, 7 bulls ready for service, and 45 young stock. The herd affords training in cattle management and dairy work to the students of the Farm School, it supplies a type of bull eminently suited to crossing with the small village cattle and throwing offspring of a not too large but stocky type that the villager likes. It is in a larger part than European cattle resistant to many of the diseases prevalent in the Island.

The herd now contains cows of the third generation since establishment and their records and performance are complete and will in another two generations afford most valuable material for selection along milk production and other traits.

The herd should be continued on the present lines and dairy instruction at Peradeniya expanded and kept up to date as the herd expands.

4. *Kangayam Cattle*

In 1926-27 it was decided to establish a herd of Kangayam draught cattle at the Experiment Station, Peradeniya, and 1 bull and 12 cows were imported from India. A smaller herd was later imported for Wariyapola. The Peradeniya herd was dispersed in 1932 with the consent of the Hon. the Minister for Agriculture when the bulls were distributed to Government Farms for draught purposes and the cows were sold by auction. The herd had reached a size when owing to very limited grazing facilities at Peradeniya it could no longer be maintained there.

The Kangayam is the type of "Coast bull" much in favour for draught purposes in the north of the Island. The Wariyapola herd should not be dispersed until some definite decisions have been come to as to the future policy for animal husbandry and if breeding herds for draught animals be decided upon this might serve elsewhere as the nucleus for this breed. At present the small herd supplies the Agricultural Department with draught cattle.

5. *Miscellaneous*

One of the future problems will have to be the improvement of the black cattle in the Island unless the alternative of supplanting them by another type be embarked upon. Nothing so far as we are aware has ever been done to see to what extent they are susceptible of improvement. As a very preliminary step a few of these cattle have been got together at the Experiment Station, Peradeniya, to examine milk yields and to make selections of a bull and cows for further experiments. Such a preliminary would be valuable when it be decided to make any further experiments to improve the breed.

There exists on the Experiment Station, Labuduwa, a small herd (now some 12 in all) of Montgomery (Sahiwal) cattle. These might for the present be continued and multiplied there, they may at a future date be a valuable nucleus for introducing Zebu blood into a cross for milk production.

III. CONSIDERATIONS FOR FUTURE WORK

We have already indicated the methods that seem to us to be likely to secure a general improvement in the neat stock for the country side.

There would seem still to remain two further problems requiring attention.

(*a*) To make some attempt to supply a large type of draught bullock than the present local animal, since in the north there is still the demand for such and the demand would become greater if the practice of dry land farming increases.

The present requirements are met by importation from South India through Kayts of animals of the Kangayam type. About 500 animals per annum is the present import.

Mr. Crawford has explained the position in his memorandum. (*b*) Something should be done to establish a selected breeding herd of buffaloes. There is a definite scarcity of these animals in some Provinces and nothing is being done at present to improve the type of buffalo in the Island. The Committee appointed to report on the Improvement of Cattle Breeding in Ceylon recommended in 1929 that there should be established on a large scale of about 5,000 acres in the Minneriya-Polonnaruwa district of the North-Central Province a farm for cattle breeding directed to making Ceylon ultimately independent of outside sources for the supply of livestock.

This idea was again reiterated by the Ministry of Agriculture in Sessional Paper VIII., 1932, in its comments on the work of the Veterinary Department. "Such a farm should be situated near the colonization areas in the dry zone—near Nachchaduwa, Minneriya and Tamankaduwa." An investigation of the matter was an instruction by the Hon. the Minister to us.

Mr. Crawford spent a week touring the district and studying conditions. We have had valuable assistance from the Revenue Officer, Mr. de Silva, at Polonnaruwa, and we all three have visited likely places and discussed the situation on the spot.

We are unanimous that the most suitable situation is to the South of the Polonnaruwa-Manampitiya road, some one mile beyond Polonnaruwa Railway Station. There is good grazing ground here, not susceptible to floods, and with proximity to water and a railway station. The area would be suitable for both neat stock and buffaloes.

A farm at this place would be in the area best suited for cattle breeding in Ceylon. Very little appears to have been done in the past to expand the possibilities of this area. A livestock farm would serve as a source of supply of better stock and a centre for dissemination of information and improved methods.

We would advise that such a farm be started, the initial stock to be as follows:

(*a*) Fifty buffalo cows purchased in Tamankaduwa area and selected for their milking qualities. To mate to these 2 bulls of Indian heavy milking Murra type would be required.

(*b*) Fifty cows purchased in Tamankaduwa of the Kangayam type which is common in that area. The existing herd of Kangayam cattle at Wariyapola to be added to this herd. This would be the nucleus of a herd for breeding draught cattle of the type favoured by the cultivators in the Northern and Eastern Provinces.

(*c*) Fifty cows purchased in Tamankaduwa of the local Sinhalese breed to be mated to Sind bulls with the object of producing a herd of grade Sind cattle suitable for the production of cheap milk. The object would be to develop a type of cow which could subsist largely on pasture and yet produce a reasonable quantity of milk.

(*d*) 100 female goats to be purchased locally and mated to male goats either of the best Indian type or of the improved English breeds.

(*e*) Four pens of poultry of one of the large egg breeds such as Minorcas or Welsummers.

A very rough estimate of the cost of establishing such a farm would be Rs. 150,000 made up as follows:

			Rs. cts.
Manager's bungalow	...	...	5,000 00
Well for Manager's use	...	...	1,000 00
Milk room and ghee making room		...	3,000 00
Cattle sheds and pens	...	...	50,000 00
Dipping tank	...	...	3,000 00
Fencing	...	...	50,000 00
Store house	...	...	2,500 00
Implements	...	...	5,000 00
Labourers' quarters	...	...	5,000 00
			124,500 00

Stock :—

		Rs. cts.	
(*a*) 50 buffalo cows	...	5,000 00	
2 buffalo bulls	...	1,000 00	
(*b*) 50 Kangayam type cows	...	2,500 00	
(*c*) 50 local breed cows and 2 Sind bulls		2,500 00	
(*d*) 100 female goats and 2 male goats		1,500 00	
(*e*) 4 pens poultry	...	1,000 00	
			13,500 00
			138,000 00
Contingencies	...	...	12,000 00
			150,000 00

Very little income could be anticipated for some years as these would be occupied in building up the stock. Later revenue could be expected from sale of stock, *e.g.*, cart bulls, cows and goats, sale of ghee, sale of eggs.

Problems connected with the improvement of poultry, sheep and goats, and pigs have been dealt with by Mr. Crawford in his survey.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31 DECEMBER, 1933

Province, &c.	Disease	No. of Cases up to Date since Jan. 1st 1933	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	33	1	31	1	1	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	15	1	...	10	...	5
	Piroplasmosis	...	...	...	...	...	...
Colombo Municipality	Rinderpest	..	...	...	...	...	...
	Foot-and-mouth disease	28	...	27	1	...	...
	Anthrax	12	...	...	12	...	...
	Rabies (Dogs)	30*	1	...	...	...	30
	Haemorrhagic Septicaemia	...	...	...	...	...	...
	Black Quarter	...	...	...	...	...	...
	Bovine Tuberculosis	...	...	...	...	...	...
Cattle Quarantine Station	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease (Sheep & Goats)	122	1	114	8	...	...
	Anthrax (Sheep & Goats)	175	...	...	175	...	...
Central	Rinderpest	65	...	11	52	...	2
	Foot-and-mouth disease	3	...	3	...	...	...
	Anthrax	10	...	...	10	...	..
	Bovine Tuberculosis	37	6	...	...	27	(destroyed 10)
	Rabies (Dogs)	...	...	...	...	..	
Southern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	86	36	85	...	1	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	1	...	...	...	...	1
Northern	Rinderpest	1778	20	374	1348	4	52
	Foot-and-mouth disease	4	..	4	...	...	...
	Anthrax	...	...	...	...	...	...
	Black Quarter	...	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	52	...	51	1	...	...
	Anthrax	...	...	...	...	..	...
North-Western	Rinderpest	...	...	...	...	..	...
	Foot-and-mouth disease	116	...	110	6	...	...
	Anthrax	...	...	..	...	...	...
	Pleuro-Pneumonia (Goats)	48	45	7	29	10	2
	Rabies (Dogs)	2	...	...	1	...	1
North-Central	Rinderpest	1192	...	227	912	...	53
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	1†	...	1	...	...	...
	Anthrax	...	...	...	...	...	..
	Bovine Tuberculosis	9	...	...	...	7	2
Sabaragamuwa	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	1388	...	1324	64	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	1	...	1	...	...	...
	Haemorrhagic Septicaemia	12	...	...	12	...	...
	Rabies (Dogs)	10	2	...	1	...	9

* 1 case occurred in a Goat at the Slaughter House. † Occurred in November.

G. V. S. Office,
Colombo, 9th January, 1934.

M. CRAWFORD,
Government Veterinary Surgeon

METEOROLOGICAL REPORT
DECEMBER, 1933

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Inches		Inches
Colombo -	84·8	−0·8	71·7	−0·6	70	90	5·0	1·16	5	− 4·49
Puttalam -	84·6	−0·2	70·2	−1·1	72	90	4·9	3·04	11	− 3·14
Mannar -	82·3	−1·3	74·1	−0·7	78	88	5·0	4·21	8	− 3·57
Jaffna -	82·1	−0·1	72·3	−0·3	73	90	4·3	9·57	9	− 1·00
Trincomalee -	80·5	−0·8	74·7	+0·3	79	86	5·8	10·06	12	− 3·63
Batticaloa -	81·2	−1·1	72·5	−1·0	81	93	7·2	18·59	17	+ 2·20
Hambantota -	84·6	+0·4	72·1	−0·6	72	88	3·8	1·35	8	− 4·05
Galle -	83·7	−0·2	73·0	−0·1	78	93	5·4	9·47	13	+ 2·77
Ratnapura -	88·2	−0·1	71·5	−0·1	74	95	5·4	6·26	14	− 2·69
A'pura -	82·6	−0·7	69·7	−0·4	72	97	6·4	3·19	8	− 5·43
Kurunegala -	85·2	−1·1	68·8	−1·7	72	95	6·2	6·67	11	− 0·22
Kandy -	81·5	−1·3	66·1	−1·5	68	89	5·2	2·55	8	− 6·23
Badulla -	75·8	−1·2	62·3	−2·3	79	94	5·8	3·78	16	− 8·39
Diyatalawa -	71·1	−1·1	56·4	−2·0	76	94	6·7	2·91	12	− 5·02
Hakgala -	67·0	−1·2	51·0	−2·1	77	84	6·6	4·14	17	− 9·17
N'Eliya -	67·3	−0·9	47·4	−1·3	71	90	5·8	2·39	14	− 5·92

The rainfall of December was below normal nearly everywhere in Ceylon, excess being reported only from a few stations in or near the Jaffna Peninsula, some places to the north and north-east of Kurunegala. the western extremity of the Southern Province, and an occasional station elsewhere. Deficits were greatest on the north-eastern slopes of the hill country, where the rainfall at this season is usually heaviest, but were well-marked over the greater part of the Island. The greatest deficit, 22·53 inches, was reported from St. Martin's estate.

Only six falls of 5 or more inches in a day were reported, all within the first quarter of the month. The highest daily fall was 8·45 inches, at Talaimannar, on the 7-8th.

Until the 11th north-east monsoon conditions prevailed, with, in general moderate rain, which was heaviest and most widespread between the 6th and 9th. About the 12th a marked steepening of the barometric gradient suggested the possibility of a depression forming in the Bay of Bengal. This soon materialized, giving a steep westerly or south-westerly barometric gradient. The storm passed out of the Bay to the Indian coast well north of the Island, but caused some fairly heavy rain and strong winds in the north-east of Ceylon. By the 16th, it had ceased to affect the Island, and a period of fairly dry weather set in, which lasted till the end of the month. What little rain fell was usually the result of local thunderstorms.

Temperatures were nearly everywhere below normal, but not markedly so. Cloud was appreciably below normal, and humidity, on the whole, a little in deficit. As a result of the depression, barometric pressure and the usual northerly gradient were both below normal, while the depression was also probably the cause of the mean wind strength being above normal.

H. JAMESON,
Supdt., Observatory